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2d Session. }

HOUSE OF REPRESENTATIVES.

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{ No. 15.

REPORT
OF
THE SUPERINTENDENT
OF THE
COAST SURVEY,
SHOWING
THE PROGRESS OF THE SURVEY
DURING
THE YEAR 1864.

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National Oceanic and Atmospheric Administration
Annual Report of the Superintendent of the
Coast Survey

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IN THE HOUSE OF REPRESENTATIVES, *January* 13, 1865.

Resolved, That there be printed three thousand extra copies of the Coast Survey for 1864, two thousand for the use of the Coast Survey and one thousand for the use of the House.

LETTER
FROM
THE SECRETARY OF THE TREASURY,
TRANSMITTING
THE REPORT OF THE SUPERINTENDENT OF THE UNITED STATES COAST SURVEY.

TREASURY DEPARTMENT, *December 20, 1864.*

SIR: I have the honor to transmit, for the information of the House of Representatives, a report by Professor A. D. Bache, Superintendent of the United States Coast Survey, showing the progress in that work during the year ending November 1, 1864; and also the manuscript map of progress brought up to the same date, as required by act of Congress, approved March 3, 1853.

I have the honor to be, very respectfully,

W. P. FESSENDEN,
Secretary of the Treasury.

Hon. SCHUYLER COLFAX,
Speaker of the House of Representatives.

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REPORT.

CAMBRIDGE, MASS., *October 26, 1864.*

SIR: I have the honor to submit, in conformity with the law and regulations of the Treasury Department, the following report on the progress made in the survey of the coast of the United States during the surveying year, which will end with the present month.

The general progress in the work under my superintendence has been summed up from time to time in previous reports. It is not now needful to recapitulate in detail, as our parties on southern sections of the coast are yet employed in local surveys to facilitate military operations, or for the use of blockading squadrons, in accordance with the policy adopted by the department at the outset of the rebellion. The large manuscript map, prepared under act of Congress of March 3, 1853, and as directed by the act, presented annually since that date, shows the progress up to the present time. In a general way the progress is shown also by the small engraved sketch (No. 37) which accompanies this report.

A brief statement of the work of the present year will be given to show the adaptation of the survey in all parts of its organization to the present requirements of the government service.

The war has not essentially changed the distribution of the working parties. About the same number as were heretofore assigned to duty on the southern coast has been in surveying service with the national forces in the rebellious States. Four parties have acted under the orders of Admiral Lee; three, with as many vessels, under Admiral Dahlgren, and two under Admiral Porter.

For the military service in Eastern Virginia and Maryland six parties were employed during parts of the season; in West Virginia three parties, at Knoxville two parties, at Nashville two, at Chattanooga five, previous to and during the movement on the rebel works at Missionary Ridge; two parties accompanied the army in Louisiana and Texas, and one was attached to the Florida tax commission.

From the several officers in whose commands the parties were associated warm acknowledgments have been reiterated as to the importance of the services rendered, and their bearing on the success of military and naval operations. The body of the report will contain, as usual, notices of the work in detail. Very brief mention will here be made of the localities and nature of this class of operations, and after it mention of the advance made in the regular progress of the survey of the coast.

SERVICE WITH ARMIES AND BLOCKADING SQUADRONS.

The survey has been kept in full co-operation with the blockading squadrons, and with the armies of the Union, as heretofore. In the vicinity of Baltimore the survey of ground connected with the defences has been continued by Sub-Assistant Iardella, and during part of the season by Assistant C. M. Bache. The topography of the approaches to the capital has been further extended beyond the northeast boundary of the District of Columbia, by Sub-Assistant Ferguson. A minute topographical survey has been made of Arlington Heights by Messrs. Hergesheimer and McMath for the War Department, and special determinations for the effective use of heavy artillery at Washington, New York, and Boston, by Assistant Schott. Sub-Assistant Donn is now engaged in surveying the approaches to the fords of the Potomac above and below Harper's Ferry. In West Virginia the latitude and longitude have been determined at eleven military posts by Assistant Dean and Sub-Assistant Mosman, and the magnetic variation at most of them by Mr. S. H. Lyman. At Clarksburg, Virginia, Mr. Lindenkohl assisted in compiling the military map of West Virginia, and computed the latitude of numerous points from the sextant observations of the late Lieutenant J. R. Meigs, formerly chief engineer of the department. Sub-Assistant Rockwell, before making a plane-table survey of Strawberry Plains and of the city of Knoxville and its defensive works, in which duty he was associated with Mr. R. H. Talcott, was engaged in similar service at Sewall's Point, Virginia. Assistant West, after reconnaissance duty, which terminated with the battle of Missionary Ridge, Tennessee, was in the same way employed at Bermuda Hundred, Virginia. Sub-Assistants Dorr and Donn made plane-table surveys of the environs and defences of Nashville and of Chattanooga, Tennessee, previous to the repulse of the enemy in

the south approach to that city; and Mr. Donn, in conjunction with Mr. Marindin, afterwards rendered similar service for the army near Petersburg, Virginia. Sub-Assistant Boyd has made a complete survey of the battle-field of Chickamauga, Georgia, and is now under orders to rejoin the army at Chattanooga.

In connexion with the North Atlantic blockading squadron, Mr. Strausz, and subsequently Mr. Cordell, have made resurveys of the bar and channel into Beaufort harbor, North Carolina. The last-named officer sounded the harbor, and the entire channel which leads from Beaufort through the straits and through Core sound, marking also its course by buoys and stakes. The same parties reset the buoys between the bar and Fort Macon to conform to the changes found by the resurveys. Mr. Strausz also made a resurvey of Hatteras inlet, and sounded out a stretch of six miles of the Neuse river below New Berne, marking the channels in both localities by buoys. The triangulation of the Neuse river was at the same time continued by Assistant Fairfield. Sub-Assistant Halter made a triangulation and shore line survey of Croatan sound, and of Roanoke river, North Carolina, above and below Plymouth. These waters were thoroughly sounded by Sub-Assistant Bradford, and the channel through the latter was marked by spar-buoys. He has since sounded Trents' Reach, in James river, Virginia, and is now engaged in the survey of Bogue sound. A careful reconnaissance of the Cape Lookout shoals has been made by Lieutenant Commander Phelps with the surveying steamer Corwin.

Attached to the South Atlantic blockading squadron, and for service also with the military forces, three parties with the surveying steamer Vixen, and schooners Bailey and Caswell, were assigned. Assistant Boutelle, besides the complete development of the channels at present leading into Charleston harbor, in which also Assistant Edwards was engaged during part of the season, reset the buoys, and prepared new sailing directions. Under his direction Folly river and Light-house inlet have been sounded by Sub-Assistant Webber; the hydrography of Wassaw sound has been continued, and a resurvey made of the bar and channel of the St. John's river to a point near Mayport Mills. As heretofore, his party in the Vixen, in charge of Acting Master Platt, performed the pilot service required for the vessels of the South Atlantic squadron. Sub-Assistant Dennis made surveys for defensive works at Pilatka, Florida, extended the survey of the St. John's river above Jacksonville, and during the military movements in that vicinity made a reconnaissance of the roads leading towards St. Augustine, Picolata, and Mayport Mills. At Port Royal he surveyed Bay Point and Land's End for naval purposes, and on Morris and Folly islands surveyed the shore lines of the inland passage between Light-house inlet and Folly river. Mr. McMath was on service with the United States tax commissioners for Florida, at Fernandina and at St. Augustine. He also furnished for military use a copy of the county map, showing the interior of Florida beyond Jacksonville.

In the military department of the Gulf, Assistant Oltmanns served on the staff of Major General Franklin, and made surveys along the route of the 19th army corps, including the environs of Vermilionville, Opelousas, Washington, and Franklin, Louisiana. Sub-Assistant Hosmer was present with the army detachment at Aransas Pass, Texas, and located the position of the rebel works on a map, after determining the changes that had taken place in the depth of water on the bar of that pass. He performed similar duty at Pass Cavallo, traced and marked the changes which had occurred at the eastern end of Matagorda island, and buoyed the channel into McHenry bayou. After joining the staff of Brigadier General Grover, in January, Mr. Hosmer made surveys at Madisonville and Morganza, Louisiana, and at Fort Adams, Mississippi. Both of these officers accompanied the army of Major General Banks through the Red river campaign.

On the Mississippi river, and for the use of the squadron under Admiral Porter, Assistant Gerdes made a topographical survey of Grand Gulf and its vicinity, and sounded the channel abreast of that post. This was followed by a reconnaissance which included the shore and channel of about fifty miles of the course of the Mississippi, between Rodney and Vicksburg. He made also a minute survey of the Ohio river and its shores from Mound City to Cairo, Illinois, with soundings relative to inquiries concerning a navy yard site. Sub-Assistant Fendall assisted in this important survey, and was afterwards on duty with the gunboats which passed up Red river to act in concert with the land forces.

The transfer of some of these parties from one locality to another, as service required, has been noticed in the abstract just given; the transfer of others therein mentioned for prosecuting the usual work of the survey will appear in the short summary which follows.

GENERAL STATEMENT OF PROGRESS.

In connexion with the following summary, it should be borne in mind that many of the operations referred to under the preceding head have added to the material requisite for the usual publications of the survey.

In the northern sections of the Atlantic coast the regular operations of the survey have been continued, and the parties here enumerated are now at work : Sub-Assistant Dennis, in the topography of the lower part of Passamaquoddy bay, Maine ; Assistant Fairfield, in coast triangulation near Mount Desert island ; and Assistant McCorkle, in similar duty in Penobscot river, near Bangor ; Sub-Assistant Dorr, in the topography of islands at the entrance of Penobscot bay ; Sub-Assistant Ferguson, at the entrance of St. George's river, Maine ; Assistant West, on the shores of Boothbay, Maine ; Mr. McMath, on the east side of the Sheepscot river ; Assistant Adams is completing plane-table work on the shores of the water passages which enter the Kennebec, near Bath, Maine ; Assistant R. M. Bache, on the shores of the Kennebec, above Bath ; and Sub-Assistant Longfellow, on the survey of islands on the east side of Casco bay. Sub-Assistant Webber has sounded the St. George's river, Maine, and its approaches ; Mr. Strausz, the waters of Quohog bay, Maine ; and Lieutenant Commander Phelps has extended the hydrography eastward of the approaches to Portland entrance. Assistant Mitchell has examined the known dangers to navigation in Eastport harbor and Muscle Ridge channel, (Penobscot bay,) and indicated the position of desirable aids to navigation. He has also continued work connected with the special survey of Boston harbor for the United States commissioners. The detailed survey of the shores of Narragansett bay is in progress by Assistant Harrison and Sub-Assistant Hosmer. On the coast of Connecticut the work of connecting the primary base lines in Sections I and II has been continued by my own party, and Assistant Blunt has extended the triangulation which connects the primary work with points on the Hudson river. The detailed topography of the shores of the Hudson has been extended by Assistant Whiting near Sing-Sing and Haverstraw. The hydrography near Sandy Hook has been re-examined by Assistant Mitchell, the results, as heretofore, having reference to the labors of the engineer department. Assistant C. M. Bache has been engaged at the highlands of Navesink, New Jersey. The work of verification on the coast of New Jersey has been extended by Assistant Farley to include Absecon inlet ; the shores of Absecon harbor have been resurveyed by Mr. H. W. Bache, and the hydrography of the approaches and of the inlet executed by Lieutenant Commander Phelps. Assistant Mitchell made a special examination relative to the effect of the ice drift in the Delaware river during the winter of 1863-'64 for the Navy Department.

Tidal observations have been kept up at the permanent stations, at Eastport and Portland, Maine, Charlestown, Massachusetts, in New York harbor, and at Old Point Comfort ; and magnetic observations at Eastport and Key West.

On the Pacific coast of the United States the triangulation along the Santa Barbara channel and between Monterey bay and San Francisco has been continued, and that of Suisun bay is in progress. The topography and in-shore hydrography between Point San Pedro and Tunitas creek have been completed, and a resurvey has been made of Mare Island strait, including the approaches to the navy yard.

The great enhancement of prices during the present year has unavoidably been felt in our operations. It is, however, a matter of gratification that the results here sketched compare favorably with those of the preceding years of the war. On the Pacific coast only has the progress of the work been sensibly retarded by the effect of the basis of currency in use there.

In office-work numerous direct calls have been met from generals and naval officers for tracings on the full scale of such sheets of the Coast Survey as were applicable to their purposes ; these have been very generally found available in siege operations and in blockading service. Copies of maps for immediate use have in all cases been furnished to the naval and military commanders, to whose forces the parties have been attached. The tangible evidence of utility thus presented to a class of minds eminently practical has continued to elicit the warm commendation which marked our first connexion with the military and naval forces of the government at the outset of the war.

Of the regular charts of the Coast Survey nearly thirty-seven thousand copies have been distributed during the past year. In this aggregate are included twenty-three thousand copies which were supplied to the navy.

The compilation of maps for use in the armies and to illustrate their operations has been continued, and the several sheets include, on a uniform scale, by far the greater part of the area of the States in rebellion. The region embraced in the great campaign of Major General Sherman beyond Chattanooga was mapped at the office at his request, and by diligent exertion the sheets intended for the use of his army were completed and forwarded before the opening of the campaign.

The call from public officers in the civil and military service for this class of information has become general. Of all kinds, (excluding charts,) seventeen thousand copies have been distributed or sold during the year, the sales, as heretofore, reimbursing for the publication.

The descriptive memoirs of the southern coast, which were prepared at the outbreak of the rebellion, and intended for the exclusive use of naval and military commanders, retain their interest, and have been supplied, as heretofore, when calls were made for them.

OFFICE-WORK.

SECTION I. Sheet No. I, of a general chart of the Atlantic coast of the United States, scale 1:1,200,000, (Cape Sable to Sandy Hook,) has been drawn and engraved; a new edition of Nantucket shoals, with additions, has been prepared, and Rockland harbor, as a preliminary chart, has been completed. The drawing and engraving of coast charts No. 7, (Muscongus bay to Portland,) No. 8, (Seguin island to Kennebunkport,) No. 10, (Cape Ann to Plymouth,) No. 11, (Plymouth to Hyannis,) have been continued; progress has been made in the engraving of the charts of Kennebec and Sheepscot rivers, Barnstable harbor and Newport harbor. The drawing of Eastport harbor and approaches, and the drawing and engraving of a new edition of Boston harbor, embracing the resurvey for the harbor commission, have been commenced.

SECTION II. The drawing and engraving of a preliminary chart of Hudson river, sheet No. 3, (from Poughkeepsie to Troy,) have been completed; that of the finished chart of Hudson river, sheet No. 1, (from New York to Haverstraw,) and of coast chart No. 21, New York bay and harbor, (finished topography,) have been continued; and the drawing of a chart of Absecom inlet has been commenced.

SECTION III. A chart of Hampton Roads and Elizabeth river has been engraved. Progress has been made in the drawing and engraving of coast chart No. 28, (Cape May to Isle of Wight;) coast chart No. 29, (Isle of Wight to Chincoteague inlet;) Potomac river, sheet No. 1, (from the river entrance to Piney Point;) and Potomac river, No. 4, (from Indian Head to Little Falls.) The drawing of the general chart of Chesapeake and Delaware bays has been continued; that of a map of the approaches to Baltimore for military purposes has been commenced; additions have been made to the lithographic map of Virginia and southeastern Virginia; and a map of part of Virginia and North Carolina, on a scale of ten miles to the inch, has been drawn and engraved on stone.

SECTION IV. A preliminary chart of Cape Lookout shoals has been drawn and engraved; the drawing of additional surveys on coast charts Nos. 40 and 41, (Albemarle sound;) and a preliminary chart of the mouths of Roanoke river has been completed and the engraving commenced. Progress has been made in the engraving of coast chart No. 48, (Cape Fear and approaches,) and a tinted lithographic edition of the same has been printed for the use of the navy. New editions of the entrances to Beaufort harbor and Hatteras inlet, from resurveys, have been published.

SECTION V. The drawing and engraving of coast chart No. 53 (from Rattlesnake shoals to St. Helena sound) have been continued; and work on No. 54 (from St. Helena sound to Ossabaw sound) has been commenced. Progress has been made in the drawing and engraving of St. Helena sound, Port Royal sound, Beaufort river, South Carolina, and the inland passage from St. Helena to Port Royal sound through Harbor river, Stony river, and Station creek; and in the engraving of Wassaw sound, with the inland passage from Port Royal sound to Tybee Roads, through Skull creek and Calibogue sound. A new edition in tint of Charleston harbor, showing the resurvey of the bar, and a sketch of Light-house inlet, have been prepared. A military map of parts of Georgia and South Carolina has been drawn and engraved on stone.

SECTION VI. The engraving of the Atlantic coast, sheet No. 4, (Mosquito inlet to Key West, including the Bahama banks,) of the western end of Florida reefs, including Tortugas islands, of a new edition of Key West harbor, and of additions to general coast chart No. X, (straits of Florida,) has been completed. Progress has been made in the drawing and engraving of coast chart No. 69, (Florida reefs, from the Elbow to Matecumbe key,) and of No. 70, (Long key to Newfound Harbor key.) A preliminary chart of the main entrance to Charlotte harbor, Florida, has been commenced, and a military map of the northern part of Florida has been drawn and engraved on stone.

SECTIONS VII, VIII, and IX. A general chart of the Gulf coast, from Key West to the Rio Grande, has been drawn and engraved; the engraving of coast chart No. 100 (Point au Fer to Marsh island, Louisiana) has been continued, and additions have been made to coast chart No. 108, (Matagorda and Lavacca bays, Texas.) A new edition of Mobile bay and approaches has been prepared in tint; maps of the approaches to Vicksburg and Grand Gulf, Mississippi; and of the Mississippi river and its shores from Rodney to Palmyra bend; and military maps, embracing the States of Mississippi, Alabama, and part of Georgia, on a scale of ten miles to the inch, have been drawn and engraved.

SECTIONS X and XI. The drawing and engraving of Tomales bay, as a finished chart, and of Half Moon

bay, as a preliminary chart, have been completed. Progress has been made in the drawing and engraving of Bodega bay, upper part of San Francisco bay, and chart of the Pacific coast from Point Pinos to Bodega Head. A new edition has been prepared of Washington sound, with additions and corrections, and additions have been made to the other plates previously engraved.

MAPS AND CHARTS.

In the regular progress of the work of publication, many of the early sketches and preliminary editions of charts, issued to make the information obtained by the survey available to the public as soon as practicable, are superseded by or absorbed in the more finished charts, which are prepared as the information accumulates, especially those which embrace the whole coast in a connected series, on a scale of $\frac{1}{800,000}$. This process must be kept in mind when following the reported advance of various maps and charts from year to year, and in comparing the catalogue of charts (Appendix No. 10) now issued by the Coast Survey Office to the government vessels, or sold to the commercial marine, with annual statements of plates engraved. Thus a chart of an important locality will be first published with the bare shore-line, soundings, channel curves, and sailing directions—an incomplete form—but still containing the information most important for the navigator. While an electrotype copy of this plate is used for printing, the engraving of the original is continued; the shoals are made conspicuous by sanding; other hydrographic details are added as they are developed by the survey; and the outlines of the topography are engraved, bringing the map to a second stage, in which it is again issued, superseding the first, but still remaining a preliminary edition. This also is printed from electrotype copies, while the original is receiving the finished representation of topography, as hills, woods, fields, marsh, &c., together with views, and all requisite notes and tables, so as to form at length the finished map, which alone is retained in the catalogue.

Seventy-four sheets have been worked upon in the drawing division within the past year. Fourteen of this number were first-class maps and charts of large size; eight first-class, and twenty-four preliminary harbor charts and sketches; twelve sheets were intended for engraving on stone, or for photographic reduction, and sixteen were progress sketches. Fifty-six sheets have been completed, and eighteen are in progress. Of the hydrographic sheets completed, two are large charts of the coast series, and twenty-six harbor charts, most of which were for issue in preliminary form.

In the engraving division two first-class maps and charts have been completed within the year. Eight plates of second-class charts and sketches have also been engraved, and two diagrams. Nine preliminary editions have been engraved preparatory to their final completion. Twenty-three plates are now in progress, of which five were commenced within the year. This gives a total of twenty-four plates completed, and twenty-three in progress, or forty-seven plates worked upon during the year.

All the details in regard to the production and distribution of maps and charts will be found in the report of the assistant in charge of the office. (Appendix No. 10.)

The following is a list of charts arranged in geographical order which are either the result of the present season's work, or, having been heretofore prepared, have not yet appeared in any annual report, for reasons of public policy, although issued to public vessels. Such of this number as it may be deemed expedient to publish at the time will appear with this report, as will some others which have not heretofore been published in any annual report in the present finished state, viz: the three sheets of Long Island sound, and the upper three sheets of Chesapeake bay, together with the necessary sketches, to illustrate the progress of the survey:

Eastport harbor, Maine.

Rockport and Camden harbors, Maine.

St. George's river, Maine.

Kennebec and Sheepscot rivers, with Boothbay harbor, Maine.

Lynn harbor, Massachusetts, resurvey of 1864.

Boston bay and approaches, coast chart No. 1, (preliminary edition.)

Bristol bay, Rhode Island.

Newport harbor, Rhode Island.

Absecon inlet, New Jersey.

Potomac river, sheet No. 1, from the entrance to Piney Point.

Potomac river, sheet No. 2, from Piney Point to Lower Cedar Point.

Potomac river, sheet No. 3, from Lower Cedar Point to Indian Head.

Potomac river, sheet No. 4, from Indian Head to Little Falls.

James and Appomattox rivers, from City Point to Richmond and Petersburg.
 Albemarle sound, eastern part, coast chart No. 40, (new edition.)
 Albemarle sound, western part, coast chart No. 41, (new edition.)
 Mouths of Roanoke river, North Carolina.
 Core sound, North Carolina.
 Cape Lookout shoals, North Carolina.
 Cape Fear and approaches, with the river to Wilmington, North Carolina, coast chart No. 48.
 Charleston bar, resurvey of 1864.
 Light-house inlet, and inland passage to Folly river, South Carolina.
 Stono inlet, South Carolina.
 Coast of South Carolina, from Rattlesnake shoals to St. Helena sound, coast chart No. 53.
 Coast of South Carolina and Georgia, from St. Helena sound to Ossabaw sound, coast chart No. 54.
 Beaufort river, Station creek, Story and Harbor rivers, with inland passage between Port Royal and St. Helena sounds, South Carolina.
 Port Royal entrance, South Carolina, survey of 1863.
 Calibogue sound and Skull creek, forming the inland passage between Tybee roads and Port Royal sound, South Carolina.
 Wassaw sound, with Wilmington and Tybee rivers, Georgia.
 Ossabaw sound, Georgia.
 Sapelo sound, Georgia.
 Altamaha sound, Georgia.
 St. Simon's sound, Georgia.
 Charlotte harbor, Florida.
 Mississippi river, reconnaissance from Rodney to Palmyra bend, Mississippi.
 Ohio river, from Mound City to Cairo.
 Western coast of the United States, from San Diego to Point Reyes.
 Western coast of the United States, from San Francisco to Umpquah river.
 Western coast of the United States, north of Umpquah river.
 Pacific coast, from Point Pinos to Bodega Head.
 San Francisco bay, upper part.
 A list is given, at the close, of such of these charts and others that are intended to accompany this report.

ESTIMATES.

The estimates here submitted are designed to carry forward the work required on the eastern part of the Atlantic coast, and to provide for the progress which may be feasible on the southern part and in the Gulf; to continue the work on the Pacific coast, and to provide for the assignment of special parties as heretofore, with the concurrence of the department, for service with the fleets and armies.

The estimates for progress on the Atlantic, Gulf coast, Florida reefs, and western coast of the United States, are given, as usual, in separate items, and are exclusive of the aid formerly, but not now, extended for the work, by the detail of officers of the army and navy.

Estimates in detail.

For general expenses of all the sections, namely, rent, fuel, materials for drawing, engraving, and printing, and for transportation of instruments, maps, and charts; for miscellaneous office expenses, and for the purchase of new instruments, books, maps, and charts..... \$19, 000

SECTION I. *Coast of Maine, New Hampshire, Massachusetts, and Rhode Island.* FIELD-WORK.—

To continue the triangulation of *Passamaquoddy bay*, and to extend it so as to include the northeastern boundary along the *St. Croix river*; to complete the secondary triangulation of the coast of Maine east of *Mount Desert island*; to continue the topography of *Passamaquoddy bay* and its dependencies; to complete that of *Prospect harbor*, and commence that of *Goldsborough bay*, (coast of Maine;) to continue that of the islands at the entrance of *Penobscot bay*, and the western shore of the bay above *Camden*, and that of the adjacent shores of *Muscongus sound*; to complete the topography of the *Damariscotta river*, and of the eastern shore of the *Sheepscot river*, and to complete the survey of the eastern shores of *Carco bay*; to continue the detailed

survey of the shores and islands of *Narragansett bay*; to continue off-shore soundings along the coast of Maine, and the hydrography of *Passamaquoddy bay*, *Frenchman's bay*, and approaches of *Penobscot bay*, and *Goldsborough, Prospect and Winter harbors*; to continue tidal and magnetic observations at Portland, and tidal observations in the progress of the hydrography. OFFICE-WORK.—To make the computations required for and reductions from the field observations; to continue the drawing of coast chart No. 1, *Passamaquoddy bay*; to continue the drawing and engraving of coast chart No. 6, approaches of *Penobscot bay*; of No. 7, *Pemaquid Point to Cape Elizabeth*; of No. 8, approaches to *Casco bay*; of No. 10, coast of Massachusetts, from *Cape Ann to Plymouth*, and of No. 14, *Narragansett bay and approaches*; to continue the drawing and engraving of general coast chart No. 1, *Quoddy Head, Me., to Cape Cod, Mass.*; to complete the drawing and engraving of charts of *Eastport harbor and Rockland harbor*; to continue the drawing and engraving of *Winter harbor, Rockport, and Camden harbors, and Tennant's harbor*; and of *Herring Gut and St. George's river and approaches*; of the *Damariscotta river* and of *New Meadow harbor*; and to complete the drawing and engraving of charts of the *Sheepscot river, Me.*, of *Newport harbor*, and of *Providence river, R. I.*, and to engrave the resurvey of *Boston harbor*, will require.....

\$62, 000

SECTION II. *Coast of Connecticut, New York, New Jersey, Pennsylvania, and part of Delaware.*

FIELD-WORK.—To complete the observations required for connecting the *Epping base*, in Section I, with the *Fire Island base*, in Section II; to continue the triangulation of *Connecticut river*, between Higganam and Hartford, and that of the *Thames river*, above New London; to continue verification work on the coast of *New Jersey*, south of Absecom inlet; to continue the topography of the shores of the *Connecticut and Thames rivers*, and the detailed survey of the shores of the *Hudson*, above Haverstraw; to execute such supplementary hydrography as may be required in *New York bay* and *Delaware bay*; to continue the tidal observations. OFFICE-WORK.—To make the computations and reductions; to continue the engraving of coast chart No. 21, *New York harbor*, and its approaches, (new edition;) and to commence the drawing and engraving of coast chart No. 22, from *Sandy Hook to Barnegat*; to continue the drawing and engraving of sheet No. 2, of the chart of *Hudson river*, (from Haverstraw to Poughkeepsie;) and of a chart of the *Connecticut river*: and to complete the engraving of coast chart No. 28, from Cape May, N. J., to Isle of Wight, Del., will require.....

17, 500

SECTION III. *Coast of part of Delaware and that of Maryland, and part of Virginia.*

FIELD-WORK.—To continue astronomical and magnetic observations in the section, and secure the stations of the triangulation; to make extensions of the triangulation for including the detached plane-table surveys in the vicinity of *Washington city*; to complete the topography near *Washington*, required for defensive purposes, and continue that of the eastern shore of Virginia; to make such detailed surveys as may be necessary at points on the *Potomac, Rappahannock, and James rivers*; and to continue the off-shore hydrography and tidal observations in the section. OFFICE-WORK.—To make the computations from field-work; to draw maps of the approaches to *Baltimore and Washington*; to continue the engraving of coast chart No. 29, (from *Isle of Wight, Del.*, to *Chincoteague, Va.*;) and of No. 30, from *Chincoteague to Great Machipongo inlet, Va.*; to continue the engraving of coast chart No. 30 bis, (*Chesapeake entrance*;) and general coast chart No. IV, (*approaches to Delaware and Chesapeake bays*;) and to commence the drawing and engraving of a chart of *James river, from Newport News to City Point*, will require.....

14, 500

SECTION IV. *Coast of part of Virginia and part of North Carolina.*

FIELD-WORK.—To complete, if practicable, the primary triangulation of *Pamplico sound*, and make the requisite astronomical and magnetic observations; to continue the triangulation of *Pamplico river*; to continue the triangulation and commence the topography of the shores of *Neuse river*; to complete the topography of the outer coast of *North Carolina*, between *Hatteras inlet and Core sound*; to continue the in-shore and off-shore hydrography in the vicinity of *Cape Lookout*; and to execute that of *Pamplico river*, and such other soundings as may be required in the waters of *Pamplico or Albemarle sounds*; to make observations of the tides and currents. OFFICE-WORK.—To make the computations and reductions; to commence the drawing and engraving of general coast chart No. V, from *Cape Henry to Cape Lookout*; to continue the

engraving of coast chart No. 38, (from <i>Currituck, Va.</i> , to <i>New inlet, N. C.</i> ;) and of coast charts Nos. 46 and 47, (from <i>Cape Lookout</i> to <i>Barren inlet</i> ;) and the drawing and engraving of a chart of the <i>Neuse river</i> ; and to complete the engraving of coast chart No. 48, <i>Cape Fear and approaches</i> , will require.....	\$15, 000
SECTION V. <i>Coast of part of North Carolina and that of South Carolina and Georgia.</i> FIELD-WORK.—To execute such triangulation and topography as may be practicable in places not yet embraced in the survey; to execute the hydrography that may be required, and additional soundings in the shifting bars in this section, with tidal observations. OFFICE-WORK.—To continue the engraving of coast chart No. 53, (from <i>Rattlesnake shoal</i> to <i>St. Helena sound, S. C.</i> ;) to continue the drawing and engraving of No. 54, (from <i>Fripp's inlet, S. C.</i> , to <i>Ossabaw sound, Ga.</i> ;) to continue the drawing of No. 57, (from <i>Sapelo sound</i> to <i>St. Andrew's sound, Ga.</i> ;) and that of general coast chart No. VII, (from <i>Winyah bay, S. C.</i> , to <i>St. John's river, Fla.</i> ;) and continue the engraving of the last-named chart; the resurvey of <i>Charleston harbor</i> entrance, and the drawing and engraving of the <i>inland passage</i> between <i>St. Helena</i> and <i>Port Royal sounds, S. C.</i> , and of <i>Wassaw sound, Ga.</i> , will require.....	17, 000
SECTION VI. <i>Coast keys and reefs of Florida.</i> —(See estimates of appropriation for these special objects.)	
SECTIONS VII, VIII, and IX. <i>Part of the western and northern coast of Florida and the coast of Alabama, Mississippi, Louisiana, and Texas.</i> FIELD-WORK.—To execute such triangulation, topography, and hydrography, in continuation of the surveys in these sections, as may be practicable, and such special surveys as may be required for public service. OFFICE-WORK.—To continue the computations and reductions of previous field-work; to continue the engraving of coast charts Nos. 84 and 85, (western coast of Florida from <i>Ocilla river</i> to <i>Cape St. Blas</i> ;) the drawing of No. 96, (<i>delta of the Mississippi</i> ;) and that of general coast chart No. XIV, (north-eastern coast of the <i>Gulf of Mexico</i> ;) to continue the engraving of the last-named chart, and to commence the engraving of general coast chart No. XVI, (western coast of the <i>Gulf of Mexico</i> ;) will require.....	36, 000
Total for the Atlantic coast and Gulf of Mexico.....	\$181, 000

The estimates for the Florida coast, keys, and reefs, and for the western coast of the United States, (California, Oregon, and Washington Territory,) are intended to provide for the following purposes:

SECTION VI. <i>Coast, keys, and reefs of Florida.</i> FIELD-WORK.—To continue, if practicable, the survey of the eastern coast of the peninsula south of the present limit at <i>Matanzas inlet</i> , or north of <i>Indian river</i> ; to complete the triangulation of keys inside of the Florida reefs and between <i>Chatham bay</i> and <i>Cape Sable</i> ; to continue the topography of those in <i>Chatham bay</i> , and complete that of <i>Charlotte harbor</i> ; to complete the hydrography of the approaches to that harbor, and run off-shore lines of soundings from the reef and from the coast of this section; to continue magnetic observations at <i>Key West</i> , and such tidal observations as may be requisite. OFFICE-WORK.—To compute the results of field-work; to complete the drawing and engraving of coast charts Nos. 69 and 70, (<i>Florida reefs</i> , from the <i>Elbow</i> to <i>Newfound Harbor keys</i> ;) and general coast chart No. X, (<i>Florida reefs</i> , from <i>Key Biscayne</i> to the <i>Marquesas</i> ;) and to continue the drawing and engraving of a chart of the approaches to <i>Charlotte harbor</i> , will require.....	\$11, 000
SECTION X. <i>Coast of California.</i> FIELD-WORK.—To continue the coast triangulation southward of the <i>San Pedro base</i> , or northward of <i>Santa Barbara</i> , and the work for connecting the <i>Santa Barbara</i> islands by triangulation with the coast of California; to continue the triangulation northward from <i>Bodega</i> , and to execute that of <i>Suisun bay</i> ; to continue the topography of the islands in <i>Santa Barbara channel</i> , that of the shore of <i>Bahia Ona</i> , that of the coast north of <i>Bodega Head</i> , and to complete that of <i>Suisun bay</i> ; to complete the hydrography of <i>Suisun bay</i> ; to run off-shore lines of soundings from the principal headlands of the section; to extend the in-shore hydrography northward of <i>Bodega</i> , and re-examine bars subject to change in <i>San Pablo bay</i> ; to continue tidal observations at <i>San Diego</i> and <i>San Francisco</i> . OFFICE-WORK.—To make the computations from field-work; to complete the drawing and engraving of a chart of <i>Half-moon bay</i> , the engraving of the resurvey of <i>Mare Island straits</i> , and of the upper sheet of <i>San Francisco bay</i> , and of a chart of <i>Suisun bay</i> ; to continue the drawing and engraving of a	

general coast chart of the Pacific, (from *San Diego to Point Conception*,) and of a chart of *San Francisco bay*, to be issued in one sheet.

Also, for the operations in—

SECTION XI. *Coast of Oregon and that of Washington Territory.* FIELD-WORK.—To make the astronomical and magnetic observations required in this section, or in Section X; to continue the triangulation of *Washington sound* in connexion with former work, and to make such plane-table surveys in continuation of previous work as may be practicable; to continue the hydrography in *Admiralty inlet*, or execute soundings in such special localities of *Oregon or Washington Territories* as may be called for by public interests; to continue tidal observations at Astoria, and make such as may be required by the hydrography. OFFICE WORK.—To continue the computations of field-work; to continue the drawing and engraving of surveys, as far as now made, for charts of *Koos bay, Gray's harbor, Washington sound, Admiralty inlet, and Puget's sound*, will require \$100, 000

The two small items following are in terms and amount the same as were asked for last year, and the third one is diminished in amount in consequence of a less number of steamers in use:
For publishing the observations made in the progress of the survey of the coast of the United States, per act of March 3, 1843 4, 000
For repairs of steamers and sailing schooners used in the survey, per act of March 2, 1853..... 4, 000
For pay and rations of engineers for three steamers to be used in the hydrography of the Coast Survey, and no longer supplied by the Navy Department..... 6, 000

The amounts thus estimated for the fiscal year 1865-'66, and the appropriations for the present year, are here given in parallel columns.

Object.	Estimates for fiscal year 1865-'66.	Appropriated for fiscal year 1864-'65.
For survey of the Atlantic and Gulf coasts of the United States, including compensation of civilians engaged in the work, per act of March 3, 1843.....	\$181, 000	\$178, 000
For continuing the survey of the western coast of the United States, including compensation of civilians engaged in the work, per act of September 30, 1850.....	100, 000	100, 000
For continuing the survey of the Florida reefs and keys, including compensation of civilians engaged in the work, per act of March 3, 1849.....	11, 000	11, 000
For publishing the observations made in the progress of the survey of the coast of the United States, including compensation of civilians engaged in the work, per act of March 3, 1843.....	4, 000	4, 000
For repairs of steamers and sailing schooners used in the survey, per act of March 2, 1853...	4, 000	4, 000
For pay and rations of engineers for three steamers used in the hydrography of the Coast Survey, no longer supplied by the Navy Department.....	6, 000	*9, 000
Total.....	306, 000	306, 000

* Formerly included in estimates of the Navy Department.

DEVELOPMENTS AND DISCOVERIES.

Under this head are included the special results of hydrographic operations, and in some cases of the topography. The particular localities in which developments were made by the hydrographic parties within the present year are stated below. The items are supplementary to the general list given in Appendix No. 4, in which the previous developments and discoveries made in the progress of the survey are arranged in geographical order.

1. Determination of the position of Birch Point ledge, with eleven feet of water in it, in Wiscasset bay and of a rock with only four feet, near Clou's ledge, in Sheepscot river, Maine.

2. White Head ground, about eight miles to the eastward of Cape Elizabeth, Maine, developed in its general direction.

3. A rock in the entrance of New Bedford harbor, Massachusetts, determined in position.

4. Development of Round shoal, with eleven feet at mean low water, outside of the four-fathom curve off Absecom inlet, New Jersey.

5. Hatteras inlet. The character and extent of recent changes in the depth of water determined by resurvey.

6. Three separate shoals developed by reconnaissance to the south and eastward of Cape Lookout, North Carolina.

7. Beaufort harbor, North Carolina, re-examined, and its hydrographic changes determined.

8. Two new channels developed, leading into Charleston harbor, South Carolina, resulting from changes in the direction of the former channels and shoaling in the Lawford channel.

9. Hydrographic changes determined at the bar and in the channel of St. John's river, Florida.

10. Mare Island strait resurveyed, and changes developed in the vicinity of the navy yard.

11. Special examination of the flat in San Pablo bay, between San Pablo and Pinole Point.

SPECIAL SURVEYS.

The physical survey of Boston harbor has been continued under my direction by Assistant Henry Mitchell. Most of the work of the present season was confined to the tabulation and arrangement of data needed by the commission, authorized to advise in regard to the preservation of the harbor. The commission, as stated in previous reports, consisted of the late Chief Engineer, General Joseph G. Totten, Admiral C. H. Davis, and myself. The expenditures for the work, as heretofore, have been defrayed by the city authorities of Boston.

At the request of the Navy Department a special examination was made in the course of last winter as to the effect of floating ice in two localities of the Delaware river, which had been under consideration as sites for a navy yard.

Numerous surveys which might be noticed under this head, being specially called for by generals in command of armies in the field, will be mentioned under the heads of sections in the report corresponding to the localities of the work.

TIDE TABLES FOR MARINERS.

The tide tables for the use of navigators are given in a revised form in Appendix No. 8. In addition to the usual number printed with the annual report, one thousand copies were prepared in pamphlet form during the first year of the war. These have been distributed from the Coast Survey office or from the Naval Observatory for the use of government vessels.

The mean interval between the time of the moon's transit and the time of high water at Old Point Comfort is corrected in the tables of this year from the latest observations.

A report on the field and office work connected with tidal stations is given in Appendix No. 9, and the office occupation of the tidal division in Appendix No. 10. With the former is included a general description of the peculiarities observed in the tides at Tahiti, the largest of the Society islands in the South Pacific ocean.

INFORMATION FURNISHED.

A list showing special items of information furnished from the office during the year is given in Appendix No. 2. While calls arising in the ordinary course of enterprise have been lessened, those connected with military and naval operations have largely increased. Besides the items given in the list, numerous applications belonging to the same general class, but more local in character, have been answered at the office.

The regulation of the department requiring acknowledgment in the title of any publication embodying information procured from the Coast Survey office has been strictly observed.

In addition to the matter usually given under this head, assistance has been rendered to the artillery department of the army for the determination of ranges of ricochet gunnery with fifteen-inch and twenty-inch guns. The experiments were made under the direction of General A. P. Howe, inspector of artillery United States army, and the operations for measuring the ranges of each impact of the projectile are stated at length in the Appendix, Nos. 21 and 22, by Assistant Schott. He also furnished a set of equations determining the trajectory of ricochet shot, and applied them in practice to illustrate their use. Mr. Schott visited two batteries on the Potomac, three forts in New York harbor, and one in Boston harbor, where the necessary measurements were taken. At each of these places temporary frameworks were erected, and the range lines were marked for given lines of fire.

GEOGRAPHICAL POSITIONS.

In Appendix No. 15 the publication of geographical positions is resumed in part, in continuation of similar lists given biennially in my report for 1859 and preceding years. The register of positions on the southern coast is still reserved in the office. The total number of positions thus far given in latitude and longitude deduced from the triangulation is eight thousand two hundred and seventeen. Any small differences between the publications since the year 1851 are due to the effect of later and accumulated material, geodetic and astronomical, which has been brought to bear on the results.

GEODESY.

The geodetic connexion of the Epping base line with the primary triangulation passing through the eastern States, offers so instructive an example of the process of reduction followed in the computations of the Coast Survey, and of the application of the method of least squares, that I have given in full Assistant Schott's report on the subject, in Appendix No. 14; that paper may be regarded as an extension of Appendix No. 33 S, in my annual report for 1854. It exhibits the combination of resulting angles from measures of directions and from measures of angles by repetition, and assigns the relative weights to the results. The residuals in the sum of the angles of the triangles are shown, and proper weights are given to the conditional equations depending upon the closing of the triangles as well as (primarily) upon the probable errors of the measured directions or angles. The thirty-five normal equations were solved by the indirect method of elimination.

The report by Mr. Schott concludes with a statement of the resulting angles and computations of the sides of the triangles.

It is proper to remark that the length used for the Epping base in this report, though very nearly so, is not the final length, which can be deduced only from certain comparisons that remain to be made.

LONGITUDE.

The computations for the longitude of American stations from the European meridian, by Pleiades occultations, have been continued under the direction of Professor Benjamin Peirce, of Harvard, according to the comprehensive plan developed by him, and before alluded to in my annual reports. His remarks (Appendix No. 11) give such promise of agreement in results as will justify the expectations founded on the adoption of the method.

The computations of differences of longitude between American stations, determined heretofore by the telegraphic method, have been continued by Dr. B. A. Gould. In addition to the results formerly reported, the longitudes of Raleigh, N. C., Wilmington, N. C., and Columbia, S. C., have been definitely settled, giving a total of twelve stations determined in longitude south of Washington. The report of Dr. Gould is given in Appendix No. 12.

The telegraphic difference of longitude between New York and Washington, deduced some years ago without the advantage of recent improvements in instruments, is somewhat uncertain. There is also a small geodetic difference which enters into that determination. It is, therefore, desirable that the telegraphic method should be again applied for a new determination of the difference of longitude between the two cities.

The list of fundamental star places, used in longitude determinations, has been submitted to a new discussion, and the declinations of the time star list have also been determined.

The investigation of the diurnal motion in azimuth of the transit instruments has been continued, and new results found strongly confirmatory of previous inferences. This subject is receiving attention in other quarters. Hereafter it must be brought into the determination of star places in order to obtain the best results practicable.

MAGNETISM.

The series of papers containing a discussion of the magnetic observations made at Girard College, Philadelphia, from 1840 to 1845, contained in some of the preceding annual reports, is brought to a close this year by the insertion of the last three parts, Nos. X, XI, and XII, contained in the Appendix, Nos. 16, 17, and 18. To facilitate the reference to the separate parts, I herewith give an abstract of the headings and general contents:

SECTION I.—Part I—Coast Survey report, 1859, Appendix No. 22—Investigation of the eleven (or ten) year period in the amplitude of the solar-diurnal variation, and of the disturbances of the magnetic declination. Part II—Coast Survey report, 1860, Appendix No. 23—The solar-diurnal variation in the magnetic declination and its annual inequality. Part III—Coast Survey report, 1860, Appendix No. 24—Influence of the moon on the magnetic declination.

SECTION II.—Part IV—Coast Survey report, 1862, Appendix No. 15—Investigation of the eleven (or ten) year period, and of the disturbances of the horizontal component of the magnetic force. Part V—Coast Survey report, 1862, Appendix No. 16—Solar-diurnal variation and annual inequality of the horizontal component of the magnetic force. Part VI—Coast Survey report, 1862, Appendix No. 17—Lunar influence on the magnetic horizontal force.

SECTION III.—Part IV—Coast Survey report, 1863, Appendix No. 19—Investigation of the eleven (or ten) year period, and of the disturbances of the vertical force; with appendix on the effect of the aurora borealis on the magnetic declination and on the horizontal and vertical force. Part VIII—Coast Survey report, 1863, Appendix No. 20—Solar-diurnal variation and annual inequality of the vertical component of the magnetic force. Part IX—Coast Survey report, 1863, Appendix No. 21—Lunar influence on the magnetic vertical force, the inclination and total force.

SECTION IV.—Part X—Coast Survey report, 1864, Appendix No. 16—Analysis of the disturbances of the dip and total force. Part XI—Coast Survey report, 1864, Appendix No. 17—Solar-diurnal variation and annual inequality of the inclination and total force. Part XII—Coast Survey report, 1864, Appendix No. 18—Discussion of the magnetic inclination and table of absolute values of the declination, inclination, and intensity between 1841 and 1845.

I proceed to a more detailed account of the contents of the three parts contained in this volume:

Part X (Appendix No. 16) analyzes the disturbances of the dip and total force. The instrumental quantities given are the differential readings of the horizontal and vertical components of the magnetic force expressed in scale divisions, and corrected for progressive change and effect of changes of temperature. Each entry was marked as a disturbance that differed as much as, or more than, ± 30 scale divisions from the normal of the vertical force, and as much as, or more than, ± 33 scale divisions from the normal of the horizontal force, and was transcribed and converted into its equivalent part of the respective force. When but one of the components was disturbed, the contemporaneous value of the other component was also inserted; a chronological table of the disturbances of the two components was thus formed, and the corresponding values of differences from the normal dip, (expressed in minutes of arc,) and from the total force, (in parts of that force,) were computed by their well-known geometrical relations. By an extended use of the criterion ± 1.1 was recognized as the limit, beyond which the disturbed values of the dip commence, and ± 0.00094 parts of the force as the corresponding limit of the total force disturbances. There remained, then, for discussion 1,446 disturbances of the dip. The first two tables contain the aggregate amount and number of disturbances of the dip for each month, divided into those which increase and those which decrease the dip; also the resulting monthly ratios and laws of progression. The next two tables exhibit the changes due to the eleven-year period, in the aggregate amount and number of disturbances, for increasing and decreasing values. The diurnal inequality of the disturbances is next shown for the aggregate amount and number, and the law of progression is exhibited for both, increasing and decreasing inclination, together with the average diurnal effect. The hours of maxima and minima, and the degree of correspondence or divergence in each case, are pointed out. Disturbances increasing the dip, upon the whole, preponderate. A table of disturbances, distributed according to their size, concludes this part of the inquiry. The disturbances, 1,470 in number, of the total force are next taken up and treated in precisely the same manner as those of the dip, and their annual and diurnal distribution, and change for the eleven-year period, are shown by means of ratios. This part concludes with tables of the average diurnal effect, and of the distribution of the disturbances of the total force according to their size. Whenever practicable, comparisons of these rather intricate laws of the disturbances with corresponding ones, deduced from the Toronto observations, are instituted and commented upon.

Part XI (Appendix No. 17) treats of the solar diurnal and annual inequality of the dip and total force. The combination of the two experimental components to form the dip and total force was effected as follows: Owing to the eleven-year inequality contemporaneous readings only, of the two parts, can be admitted for combination. The observations of the horizontal force from July, 1840, to July, 1841, are therefore here omitted. By means of a preceding paper (Part V) a table was made out of hourly values (expressed in scale divisions, corrected for progressive and temperature changes, and freed from the larger disturbances) of the horizontal force; each value was compared with its corresponding monthly normal, and the difference converted into parts of the force. The same was done with respect to the vertical force, by means of numbers, given in Part VIII. The differential values, expressed in minutes of arc, for the dip, and in parts of the force for the total force, were then computed by the formulæ, connecting these elements with their components. The semi-annual inequality of the dip, found by comparison of the summer and winter means with the annual means,

has its turning epochs about the middle of April and October. $5\frac{1}{2}$ a. m., 1 p. m., 3 p. m., and 7 p. m. are hours of no semi-annual change; greatest change at 10 a. m.; secondary change at 6 p. m.; range 0.51 and 0.18 respectively. The diurnal inequality of the dip is shown analytically and graphically for each month, also for the summer and winter half year, and for the whole year. The general character of the last curve shows a maximum about 11 a. m., and a minimum about 5 a. m., with a range of 1.2. In summer these epochs occur earlier, range 1.5, and in winter later, range 1.0. There is also a secondary maximum and minimum. The diurnal range of the dip is greatest about the time of the equinoxes, less in winter, greater in summer. The afternoon minimum disappears about the time of the equinoxes, and is best marked about the time of the solstices. Principal epochs of the normal dip, when best marked, are 7h. 22m. a. m. in summer, 8h. 33m. a. m. in winter, and 7h. 50m. a. m. for the whole year. The semi-annual inequality of the total force has its turning epoch about the 4th of April and 12th of September. 6 a. m. and 7 p. m. are hours of no semi-annual range; greatest change about 2 a. m. and 4 p. m.; range 0.00037 and 0.00033 parts of the force. The diurnal inequality of the total force consists of a single crested curve, on the average, during the year, but in winter it assumes a double progression. The principal maximum in summer occurs about 2 p. m., and in winter one hour and a half earlier; the principal minimum in summer occurs about 10 p. m., and in winter two hours earlier. Summer range nearly 0.0009; winter range nearly 0.0004 parts of the force. The hours $6\frac{1}{2}$ a. m. in summer and $7\frac{1}{2}$ a. m. in winter are epochs of normal total force. The paper concludes with an attempt to deduce the annual inequality of the dip and total force, and is illustrated with several diagrams. (Sketch No. 38.)

Part XII (Appendix No. 18) contains the results and discussion of the observations for dip, obtained with a Robinson dip circle, the same instrument which was employed in the magnetic survey of Pennsylvania and adjacent States. The series commence in January, 1842, and terminate in July, 1844; the observations were made weekly. There are, however, some breaks. Needle No. 1 was employed, with but a few exceptional cases, throughout the series; the casual results by three other needles have been referred, by comparison, to this standard needle. The monthly and annual mean dips are tabulated, the latter indicating an annual decrease of 1.2. There is also a collection of dip results, taken at Philadelphia, compiled from various sources, and properly arranged. By grouping these the secular change of the dip is expressed by a formula involving the time and square of the time. A comparison of the observed and computed dips assigns a probable error of ± 4.8 to each represented value. The minimum dip occurs about January, 1840. The discussion closes with a table of magnetic constants for five epochs, and for the mean epoch January, 1843, of the declination, the dip, and the horizontal, vertical, and total force. A comprehensive index of all the parts is added to Appendix No. 18.

With these papers is presented one containing results of magnetic observations in the United States by the late Professor J. N. Nicollet, between 1832 and 1836, made out from the manuscript record by Assistant Charles A. Schott, under my immediate direction, and at my own expense. These results, though partly incomplete and not of an accuracy attainable by methods and instruments now in use, may, it is thought, be of use in investigating the secular change. The paper is given in Appendix No. 19. The observations had never been published, and the value of the results are enhanced because of the comparatively early period of the observations and the occupation of some localities not visited by other magnetists. It contains the magnetic horizontal force at nine stations, in Maryland, Missouri, Tennessee, Georgia, South Carolina, Mississippi, Alabama, and Minnesota; and the inclination at sixteen stations in the States just mentioned, and including also Kentucky, North Carolina, Louisiana, and Florida; also the declination at one station in Virginia. Some of the results were compared with such later ones as could be found in records by other observers.

AIDS TO NAVIGATION.

The results of a special examination made at the request of the Light-house Board, with reference to aids needed for navigation in Passamaquoddy bay and Penobscot bay, are given in Appendix No. 23. In the list which follows it (Appendix No. 24) a statement is given of the buoys set or replaced by parties while working on various parts of the coast. Acting Assistant Cordell has served during the entire season as inspector for the fifth district, and in the adjoining southern district close attention has been given to the light-house service by Assistant Boutelle.

TEN YEARS' INDEX.

The consolidated alphabetical index given with this report was prepared by Sub-Assistant F. F. Nes. It comprises references to the material of all the annual reports of the survey since the year 1853.

PART II.

In this part of the report notices will be made of each survey, including the dates, names of assistants, and statistics of the field-work. As far as practicable the triangulation will be described in the usual order, from north to south on the Atlantic coast, and from the southern boundary northward, on the Pacific coast. The topography and hydrography will in general follow in the same order.

SECTION I.

FROM PASSAMAQUODDY BAY TO POINT JUDITH, INCLUDING THE COAST OF THE STATES OF MAINE,
NEW HAMPSHIRE, MASSACHUSETTS, AND RHODE ISLAND.—(SKETCH A, NOS. 1 AND 2.)

The annual progress in this section has not been at any time lessened by the war, advantage being taken of the season of the year for the assignment of parties, as, when their services were least called for in the southern sections, or when, by the advance in military operations their services were not immediately needed. A comparison with the progress made in former years will show favorably for the work done this season.

A condensed abstract of all the operations and parties is given in Appendix No. 1. In the descriptions which here follow, the same classification will be observed generally.

Triangulation of Union River bay, Maine.—This work connects with the triangulation of Blue Hill bay, as will be seen by reference to Sketch No. 2. Assistant G. A. Fairfield, with a party in the schooner James Hall, resumed duty in this section on the 15th of August. After visiting the connecting stations on the shores of Blue Hill bay, a reconnaissance was made and signals were erected for extending the triangulation eastward to Mount Desert island, and northward to Ellsworth. The southern limit of the work is Bass harbor. The angles were measured with the ten-inch theodolite, No. 91.

Mr. Horace Anderson aided in the field-work. The note-books of the triangulation, and the usual computations have been received in duplicate at the office. A summary of the statistics is appended:

Signals erected	11
Stations occupied	14
Angles measured	116
Number of observations	1,986

Triangulation of Penobscot river, Maine.—From the vicinity of North Bucksport the triangulation of Penobscot river has been extended northward, to Bangor, by the party of Assistant S. C. McCorkle. The additional work done is shown on Sketch No. 2. For final connexion with the primary triangulation, one or two stations yet remain to be occupied on the west side of the Penobscot. Assistant McCorkle resumed field-work on the 15th of August with the schooner Torrey, and closed for the season on the 27th of October. The following is a summary of the statistics:

Stations occupied	17
Angles measured	200
Number of observations	3,192

Twenty-two signals were erected by the party in the course of the season, half the number being tripods. The angles were measured with the six-inch Gambey theodolite, No. 29.

Shore-line survey of Letite Passage, (Passamaquoddy bay, Maine.)—The plane-table survey of Passamaquoddy bay was resumed by Sub-Assistant W. H. Dennis on the 1st of August. In continuation of his previous work he traced the eastern and the north shore of Deer island, and surveyed all the islands and ledges between it and White Horse island. The plane-table sheet of the season now contains thirty miles of shore-line. Field-work was continued until the 20th of October.

Mr. S. P. Holt served as aid in this party. The schooner Caswell was used for transportation.

Sub-Assistant Dennis passed the first part of the working season in Sections V and VI.

A preliminary chart of Eastport harbor and its approaches accompanies this report as Sketch No. 3.

Survey of Manhegan and other islands off Penobscot entrance, Maine.—A shore-line survey of all the islands in the southwestern approach to Penobscot bay has been made by Sub-Assistant F. W. Dorr, aided

by Mr. F. Granger. The work is contained in three sheets, the first showing Manhegan and a number of islands immediately north of it. The second includes the Green islands, and ledges known as the northern and southern triangles. The third sheet embraces Matiniens, Ragged island, and Wooden Ball island.

The party of Mr. Dorr used the schooner Hassler for this work, between the 12th of August and the 20th of October. An aggregate of eighty miles of shore-line is represented on the plane-table sheets.

The previous occupation of Sub-Assistant Door will be stated under the head of Section VIII. His plane-table work of the preceding year is shown on the chart of Rockport and Camden harbors. (Sketch No. 4.)

Topography of St. George's river, Maine.—This work has been completed by the party of Sub-Assistant Charles Ferguson. Taking up the detailed topography at the Narrows, the survey was continued downward, and now embraces both banks of the river and the numerous islands that lie in the entrance. Maple Juice cove, Turkey cove, and Deep cove are among the indentations represented on the plane-table sheet. Its eastern limit joins with a survey made by the same party in 1862. The work of this year was commenced on the 20th of July and closed on the 25th of October. The following is a summary of the statistics:

Shore-line surveyed.....	29 miles.
Roads	14 "
Area of topography, (square miles).....	9

The schooner Bowditch was used by this party for transportation. Sub-Assistant Ferguson had been previously engaged in field-work, which will be referred to under the head of Section III.

Topography of Booth bay, Maine.—The plane-table survey of this vicinity was commenced in August by Assistant P. C. F. West. Five small harbors of more or less importance are included on the topographical sheet. The principal of these, Booth Bay harbor, besides having considerable trade, is regarded by seamen as the best "harbor of refuge" on the coast of Maine. Assistant West states that it is accessible at all times and affords protection in all winds. The survey (Sketch No. 6) extends to and includes the eastern side of the lower part of Sheepscot river, and the coast from Cape Newagen to Spruce Point, together with the islands in the vicinity. The field-work was continued until the latter part of November, with the following result in statistics:

Shore-line surveyed	45 miles.
Roads	10½ "
Area of topography, (square miles)	18

During the preceding winter and spring, Assistant West was on duty, first, with the army at and beyond Chattanooga, and afterwards in the vicinity of Richmond and Petersburg. His services there will be mentioned under the heads of Section III and Section VIII.

Topography of Sheepscot river, Maine.—The detailed survey of the eastern side of the Sheepscot river, including part of Westport, has been completed by a party in charge of Mr. R. E. McMath. Barter's island, Back river, Oven's Mouth river, and numerous islands in the lower part of the Sheepscot, are represented on the plane-table sheet.

This work was resumed on the 13th of August, and was completed on the 1st of November. The following is a summary of the statistics:

Shore-line traced.....	56½ miles.
Roads	13 "
Area of topography, (square miles)	8¾

In addition to the topographical work below Wiscasset, Mr. McMath developed the position of a rock with only four feet on it at low water. This lies four hundred metres north of Clou's ledge, in the Sheepscot river. He also determined the position of a ledge in Wiscasset bay, known as "Birch Point ledge," the bearings for which were communicated to the office. When examined, there was only eleven feet on the ledge.

Mr. McMath had been previously employed in Sections III and VI.

Topography of Arrowsic island, near Bath, Maine.—The detailed survey of the shores of the water passages between the Sheepscot and Kennebec rivers has been continued by the party of Assistant I. Hull Adams. That of the present season embraces the shores of Back river, above the Arrowsic bridge, and Hurl Gate, with the adjacent shores of Brookin's bay and Hall's bay. About four miles of shore-line were traced additional to the work previously done. The plane-table sheet shows five and a half miles of road, and the features of ground within an aggregate area of five and a quarter square miles. Field-work was commenced early in August and continued until the end of October.

Topography between the Kennebec and Androscoggin rivers, Maine.—The unfinished work on the neck or peninsula at the junction of the Androscoggin and Kennebec rivers was resumed on the 12th of August by Assistant R. M. Bache. About four miles of shore-line were run additional to the previous work, and details were filled in to extend the topography towards Brunswick, along the south shore of the Androscoggin. The additional work done by the party is embraced on the published chart of the Kennebec and Sheepscot rivers.

Supplementary topography in Casco bay.—The work of filling in with details the plane-table sheet of Great Jebeig, Cousins, Littlejohn's and other islands, and part of the Cumberland shore of Casco bay was taken up in the latter part of June by Assistant A. W. Longfellow. The shore-line had been previously traced. The contouring of the interior occupied the party until the 22d of September, the aggregate of lines run in that duty being eighty-five miles. Mr. Longfellow then traced the shore-line of the Gurnet, lying between Orr's island and Sebaskahegan or Great island. Eight miles of shore were traced in this part of the bay. The high wooded shores made it necessary to work with the plane-table by intersections. This service was continued until the 4th of November.

At the outset of the season Mr. Longfellow attended to the refitting and delivery to other assistants of the vessels left during the winter in his charge at Portland. His own party used the schooner Meredith for the duty in Casco bay.

Topography of Narraganset bay.—The shore-line survey being complete, Assistant A. M. Harrison commenced the detailed plane-table survey on the 8th of August, in the vicinity of Bristol, and continued work in the field until the 15th of November. The sheet turned in includes the shores of Warren, Barrington, and Kickemuit rivers, Bristol harbor, the entire eastern shore of Mount Hope bay, and part of the main shore of Narraganset bay, as well as the towns of Bristol and Warren, and the peninsula known as Bristol Neck.

Sub-Assistant C. Hosmer was attached to the party of Mr. Harrison, and worked with a second plane-table. He was employed in the first half of the working season in Sections VIII and IX.

The following are statistics of the topographical work of the season in Narraganset bay :

Creeks and ponds.....	17½ miles.
Roads.....	94½ "
Marsh line traced.....	16 "
Area surveyed (square miles).....	15½

Some of the previous work of this party is shown on the charts of Bristol bay and Newport harbor, given with this report as Sketches Nos. 11 and 12.

Hydrography of St. George's river, Maine.—This work was completed by the party of Sub-Assistant F. P. Webber, between the 19th of August and the 4th of November. The hydrography is embraced in two sheets, one showing the soundings between the entrance of the river and the narrows; the other the soundings above and extending as far as Thomaston. A temporary tidal station was used for each sheet.

Near the mouth of Herring Gut harbor, (Sketch No. 2,) Mr. Webber connected his work with some of the lines of soundings run by the party of Mr. Cordell in 1863.

The shore-line for the hydrographic sheets was furnished by Sub-Assistants Ferguson and Dorr.

Mr. Cleveland Abbé was attached to the party as aid during the season, and Messrs. C. P. Dillaway, Franklin Platt, jr., and M. M. Defrees during part of it.

The schooner Bailey used by the party for transportation was returned to Portland at the close of the season.

A summary of the statistics of work is appended:

Signals erected.....	24
Points determined.....	31
Theodolite and sextant observations.....	206
Angles measured.....	3,477
Miles run in sounding.....	228
Number of soundings.....	15,668

In the former part of the working season Mr. Webber had been employed in Section V.

Hydrography of Quohog bay, Maine.—The party of Acting Assistant Alexander Strausz commenced this work on the 6th of August, using the schooner G. M. Bache for transportation. A tide-gauge was set up in Lowell's cove, and from thence southward to the lower end of Bailey's island, and eastward to Small

Point peninsula, (Sketch No. 2,) the soundings were prosecuted until the 17th of October. In the northern part of the bay some boat soundings yet remain to be made after the completion of the shore-line survey.

Quohog bay being one of the most rocky of the harbors of refuge on the coast of Maine, Mr. Strausz ran special lines of soundings in all the localities known at present as being dangerous. His chart marks twenty-one such localities, the principal of which are *Charity Ledge*, with fifteen feet, about half a mile from Jaquish island, bearing east; *Sister Grounds*, with seven and a half feet, about a mile north by east of White Bull island, a little to the westward of the channel leading into Cundie's harbor, and two other rocks without name, with five feet water on them lying, respectively, off Pond and Ram islands.

Mr. Strausz was aided in the hydrography by Messrs. L. A. Sengteller and C. S. Hein. Other duty performed by the party will be mentioned under the head of Sections II and IV.

The following are statistics of the work done in this section:

Miles run in sounding.....	341
Angles measured.....	3, 145
Number of soundings.....	14, 238
Area of hydrography, (square miles).....	34

Hydrography off Portland entrance, Maine.—Within the present season soundings have been extended southward and eastward about fifteen nautical miles beyond the previous limit of the hydrography at the entrance of Casco bay.

Lieutenant Commander T. S. Phelps, United States navy, Assistant Coast Survey, took up the off-shore hydrography on the first of September, with a party in the steamer *Corwin*, and completed soundings within about fifty square miles. Some of the lines run with the steamer extend broad off, and include about sixty additional square miles, but are yet to be crossed by other lines of soundings.

The following are the statistics of the work:

Miles run in soundings.....	321
Angles measured.....	534
Number of soundings.....	1, 590

The steamer *Corwin* returned to New York early in November.

Referring to the character of the hydrography, Lieutenant Commander Phelps observes that "sufficient has been accomplished to show that vessels uncertain of their position, in thick weather, should, in approaching Portland entrance, keep in forty fathoms or more, with soft bottom."

White Head Ground, off Cape Elizabeth, coming within the limits of the work of this year, was partially developed by the soundings.

Mr. Charles Junken served as hydrographic draughtsman in the party.

Physical survey of Boston harbor.—The physical survey of Boston harbor has been continued under my direction by Assistant Henry Mitchell, who has been occasionally detailed for that work at the request of the United States commission, consisting, at the opening of the year, of the late Major General Joseph G. Totten, Professor A. D. Bache, and Rear-Admiral C. H. Davis.

This is not the place to enter upon the details of this special survey, the results of which are annually published by the city of Boston. It may suffice to say that the lessening depth in some parts of that noble harbor has long been a source of anxiety among commercial men, and a thorough examination into the causes of the shoaling has been urged.

During the past season comparatively little field-work has been done in extending the survey, but the computations and tabular statements have been advanced, and a large amount of material prepared for publication.

From the commencement of the physical survey we have been encouraged by success, which has been fully appreciated by the intelligent community interested in the results. The Coast Survey, as I have before had occasion to remark, gathers many advantages from such undertakings in the collection of useful data for wider application.

The expenses of the special survey are borne by the city of Boston.

In the "Seventh Report of the United States Commission on Boston Harbor," the following remark occurs in reference to the labors of Assistant Mitchell:

"We must say in the beginning of this division, that we have thought it indispensable to place the whole of Mr. Mitchell's report, with its tables and illustrations, in the Appendix. It will be studied by the engineers and surveyors who follow the course of our investigations, and who, without this study, would be

unable to satisfy themselves of the correctness of our conclusions. It will, moreover, be studied as a model of investigation in this branch of engineering in tidal harbors."

In the course of the year, Messrs. C. P. Dillaway, A. M. Wetherill, and J. W. Brown have served efficiently in the party of Assistant Mitchell as aids.

A preliminary chart of Boston bay and its approaches accompanies this report as Sketch No. 9.

Hydrographic examination in New Bedford harbor, Massachusetts.—At the close of the last surveying year the party of Assistant Mitchell was still on duty afloat, with the schooner Dana. After closing work at Sippican, as before reported, Mr. Mitchell determined the position of a rock in New Bedford harbor. In reporting the results of his observations, he refers to other features in the hydrography of this harbor, which may become the subject of further examination.

A chart of Sippican harbor is appended, (Sketch No. 10.)

Aids to navigation.—To obtain information needed by the Light-house Board, Assistant Mitchell was directed in August to visit Eastport harbor, Muscle Ridge channel, and Herring Gut harbor, on the coast of Maine, and to examine certain rocks reported by pilots and others as being dangers in navigation. The results of his examination, and his recommendation for buoys to mark the dangers, are given in the Appendix, (No. 23.)

Tidal and magnetic observations.—The continuous series of tidal records and monthly magnetic observations were kept up at Eastport by Assistant Edward Goodfellow until the first of April, and by Sub-Assistant A. T. Mostman until July, when the work at that station was closed, and a similar series of observations of both kinds commenced at Portland, under the care of Mr. H. W. Richardson. The record of the tides, by means of the self-registering tide-gauge, is designed here, as in the other important harbors where it is kept up, to furnish the data for predictions of the tides, besides connecting the temporary tidal observations at many stations along the coast, which are made by the hydrographic parties. The magnetic observations similarly serve to discover the secular changes in the variation, and to refer to a common period the determinations made at various times in other localities.

SECTION II.

FROM POINT JUDITH TO CAPE HENLOPEN, INCLUDING THE COAST OF THE STATES OF CONNECTICUT, NEW YORK, NEW JERSEY, PENNSYLVANIA, AND PART OF DELAWARE.—(Sketch No. 1.)

The work done in this section will be described in the usual order. An abstract showing the number of parties and the operations in which each was engaged will be found in Appendix No. 1. The several descriptions of work will be noticed as heretofore under separate heads.

Primary triangulation.—In a former report it was stated that in extending the primary triangulation for connecting the Epping base, in Maine, with the Fire Island base, (see Sketch No. 1, accompanying this report,) much difficulty had been encountered in obtaining satisfactory observations upon several of the lines across the States of Massachusetts and Connecticut, some of the lines being more than sixty miles in length. The difficulty alluded to was occasioned by unusual lateral refraction.

The line from Bald Hill to Station Ivy, both in Connecticut, is rather more than fifty-three miles long. It passes at about one-third of its length near the summit of a wooded hill, in crossing the township of Canton, Connecticut, and was frequently affected in a most remarkable manner by lateral refraction. The station Bald Hill was occupied by my party in September, 1861. Nearly all the measurements of angles centering there having been made when the temperature of the air ranged from fifty to eighty degrees Fahrenheit, it was deemed expedient to make additional observations at a season of the year when the temperature should range between forty and sixty degrees. My party was accordingly organized at Washington early in May, and placed in charge of Assistant G. W. Dean, who proceeded to Station Bald Hill, and completed in a satisfactory manner a second series of measurements of such primary angles as were deemed necessary.

After completing these observations the party was transferred to Station Wooster Mountain, in the township of Ridgefield, Fairfield county, Connecticut.

The requisite arrangements for the erection of signals and posting the heliotropers were made by Assistant Dean and Sub-Assistant R. E. Halter, while the usual preparations for occupying the stations were made as in former years by Mr. Thomas McDonnell.

The instruments at Station Wooster were in position, and every preparation had been made for commencing the geodetic operations on the 1st of July, but unfavorable weather prevented until the 14th, when the measurements of angles with the thirty-inch theodolite were begun, and were continued for two days. During

the following six weeks the atmosphere was remarkably dry and hazy, and for many consecutive days the smoke arising from the accidental burning of large tracts of forest timber in this and the adjoining States of Massachusetts and New York, rendered it quite impossible to observe upon objects at a greater distance than four or five miles from the point occupied by the observer.

In many respects the weather throughout New England during the season just closed has been very similar to that of the summer of 1854, which, no doubt, is still well remembered by most of the present residents of this section of country, and more especially by those in the State of Maine, many of whom suffered great losses from the destruction of thousands of acres of timber, numerous dwelling-houses, and other valuable property.

Station Bald Hill.—The measurements of angles at this station were commenced on the 22d of May, and completed on the 7th of June. The number of observations made with the thirty-inch theodolite by Assistant Dean was two hundred and sixty-four.

At Station Wooster Mountain the measurements of angles were commenced on the 14th of July, and completed on the 10th of October. The number of signals observed upon was thirteen, five of which were primary and eight secondary, and for this purpose sixteen hundred and sixty observations were made.

The elevations of ten stations above the sea level were determined by the measurement of vertical angles with the eight-inch Gambey theodolite, C. S. No. 57, in which fourteen hundred and sixteen observations were made.

The most distant signal observed upon during the season was at Station Ivy, and visible from Bald Hill about fifty-three and a half miles in a direct line. Three other signals were between thirty-seven and forty-two miles distant from station Wooster. The relative positions of the several stations are shown in Sketch No. 1.

The area within the limits of the triangulation completed during the season, estimated in the usual manner, is seven hundred and twenty square miles.

Magnetic observations.—The geological formation of Wooster mountain appears to be chiefly gneiss rock, which, in the immediate vicinity of its summit ridge, has been uplifted into numerous cliffs varying from twenty-five to fifty feet in height. The strata of the rock at the several out-croppings inclines at various angles, and in many different directions, and although no trap rock was found in the immediate vicinity of the geodetic station, the results obtained in determining the magnetic dip at different points near the summit of the mountain indicate the presence of trap dikes in that vicinity.

After making experimental observations at several points the magnetic station was finally located about eighty metres southwesterly from the geodetic station.

The magnetic observations consisted of one hundred and forty-six readings of the suspended magnet on three days for ascertaining the declination; and the horizontal intensity and moment of inertia were determined from two complete sets of experiments on two days. The magnetic dip was ascertained at three points from nine complete sets of observations with two needles. These observations were made by Sub-Assistant R. E. Halter, aided by Mr. F. W. Perkins, who served in my party as geodetic recorder during the season.

Meteorological observations.—The usual meteorological journals were kept by Mr. Perkins, in which were recorded two hundred and eighty-nine readings of the mercurial and aneroid barometers, and of the wet-bulb and dry-bulb thermometers, in connexion with the direction and force of the wind and character of the clouds.

All the original records were duplicated, and the requisite abstracts of angles and reductions were completed in the field.

Twenty volumes of original and duplicate records were deposited in the archives at the close of the season.

It is due to Assistant Dean to say, that, in conducting the details of operations by my party during the season just closed, his services, as in former years, have been rendered with fidelity and success.

Triangulation east of Hudson river, New York.—The triangulation connecting that of the Hudson with the primary work passing through New England was resumed on the 1st of September by Assistant Edmund Blunt, and was pushed until the 1st of November. Sub-Assistants J. S. Sullivan and A. T. Mosman were attached to the party, the latter joining on the 27th of September, after completing duty in Section I.

The following is a summary of statistics:

Stations occupied	11
Angles measured	196
Number of observations	7, 038

Sub-Assistant Sullivan is now about to take up field duty in Section III, and Sub-Assistant Mosman in Section VIII.

Triangulation of Barnegat bay, New Jersey.—The triangulation of the coast of New Jersey was resumed by Assistant John Farley, at Manasquan inlet, in the middle of August. Having made the needful reconnaissance before the close of the preceding season, the work was continued southward through Barnegat bay to a point about sixteen miles below Manasquan. Eleven stations were occupied, and thirteen points determined by eleven hundred and thirty-four angular measurements. The party of Mr. Farley continued in the field until the end of November.

Topography of Hudson river, New York.—The detailed plane-table survey of the shores of the Hudson was resumed at the previous limit above Sing Sing, and on the eastern side has been extended to Croton village. The party of Assistant H. L. Whiting took the field for this duty on the 27th of August, and was aided by Mr. H. G. Ogden. Sellers' Point and the shores of Croton river were surveyed as far up as the crossing of the Albany turnpike.

On the 6th of October the topography of the west side of the Hudson was taken up at Nyack, and continued upwards to include the village of Haverstraw. A breadth of about half a mile was given to the detailed survey. On this sheet the shore-line of Rockland lake was traced, and some remarkable features of topography, in reference to which Mr. Whiting observes: "The circular crest of hills from the 'Verdiretige Hook' to 'High Tor' (seven hundred and thirty and eight hundred and twenty feet respectively) rises abruptly from the river shore at an angle impossible to ascend, with perpendicular cliffs at the summit crest. This narrow ridge of the entire line of summits, with the steep slope of descent westward, of from four hundred to six hundred feet, to the undulating fields at the base, forms one of the most striking natural features in the whole of the river topography. As a subject for contour, it is the most remarkable that has come within my experience in Coast Survey work." Sub-Assistant Cleveland Rockwell joined the party on the 8th of October. His energy in meeting the difficulties peculiar to the work of the season are warmly commended in the report of Assistant Whiting.

The following are statistics of the topography:

Shore-line traced	21 $\frac{1}{4}$ miles.
Roads	37 "
Creeks	6 "
Marsh line	3 $\frac{1}{2}$ "
Area surveyed (square miles)	9

Field-work was continued by this party until the end of November. Mr. Rockwell had previously been on duty in Section III and Section VIII, and Mr. Ogden in Section IV.

Topography of Navesink Highlands, New Jersey.—The supplementary plane-table work needed in the vicinity of Navesink was taken up by Assistant C. M. Bache on the 11th of September, with a party, in the schooner Dana. Good progress was made in the survey until the 22d of the month, but the difficulty then existing in regard to the fluctuating increase of wages made it impracticable to retain the hands at the limit allowed by the regulations. A new crew was, therefore, employed for the special purpose of taking the vessel back to Peekskill, where she was laid up for the winter.

Sub-Assistant T. C. Bowie was attached to this topographical party. Assistant Bache had been previously employed in Section III, and Mr. Bowie in Section VIII.

Topography of Absecom inlet, New Jersey.—The plane-table survey of Absecom inlet was commenced on the 1st of November, 1863, by Mr. H. W. Bache. Work was closed on the 15th of January, by reason of the severity of the weather, and was again resumed on the 1st of July. The survey (Sketch No. 16) includes Atlantic City and Brigantine beach on the opposite side of the inlet, and the water thoroughfares inland for about two miles. Very considerable changes were noticed on comparing the shore-line with that traced in 1844.

Mr. H. G. Ogden aided in the field-work. The survey was completed on the 19th of August.

Trial Course buoys.—At the request of the Chief of the Bureau of Navigation, Admiral C. H. Davis, two buoys were set in Raritan bay, between Sandy Hook, East Beacon, and Prince's Bay light, to mark the trial course for vessels of the navy.

This service was performed by Mr. Alex. Strausz in June. The buoys were placed two nautical miles asunder, and show about twenty feet out of water. The depth at the east buoy is twenty-six feet, and at the west buoy twenty-seven feet at mean low tide.

The previous occupation of Mr. Strausz will be mentioned under the head of Section IV.

Sandy Hook.—In March last a special commission, appointed by the War Department, visited Sandy

Hook, examined the changes which had taken place in the shore-line, and made comparison of the numerous surveys. The commissioners were accompanied by Assistant Henry Mitchell, who made the last hydrographic survey of the vicinity, and had gained special information in his former employment, under my direction, while the survey of New York bay was in progress.

The hydrographic changes in the neighborhood of Sandy Hook are very slight, but the extension of the extreme point of the land, and the wear on either shore, were more rapid in the year 1862 than at any previous time. In the year 1863 the extension continued, but the wear was not so great as in the previous year.

Hydrography of Absecom inlet, New Jersey.—The approaches, inlet, and harbor at Absecom, New Jersey, were sounded out in June last by the party of Lieutenant Commander T. S. Phelps, with the steamer Corwin.

The following are statistics of the work :

Miles run in sounding	92
Angles measured	645
Number of soundings.....	6, 426

A tidal station was occupied for the adjustment of soundings on the chart. The result of the survey is given with this report as Sketch No. 16.

Later in the season the party in the Corwin was employed at the Cape Lookout shoals, and also near Portland entrance.

Special examination on Delaware river.—At the request of the Navy Department Assistant Mitchell was sent in January last to observe the action of floating ice in the neighborhood proposed as navy yard sites in Delaware river. The severity of the season afforded an opportunity of noting the worst features of such action. Every fact which seemed to bear upon the question was collected with diligence, and reported to the department.

Mr. J. W. Brown and Mr. A. M. Wetherill aided in this service.

Tidal observations.—The permanent self-registering tide-gauge at Governor's island, New York harbor, has been kept in operation by Mr. R. T. Bassett, who has also continued to make observations on a box gauge for comparison at the dock of the Hamilton Avenue ferry, in Brooklyn.

SECTION III.

FROM CAPE HENLOPEN TO CAPE HENRY, INCLUDING THE COAST OF PART OF DELAWARE, THE COAST OF MARYLAND, AND PART OF THE COAST OF VIRGINIA.

All the field-work in this section has been done, as in the preceding years of the war, with immediate reference to military or naval operations, or in connexion with purposes of defence. A great amount of geographical data has thus been collected from localities intended to be embraced in the regular operations of the survey. The work done will be described under the usual heads. A synopsis showing the locality in which each of the parties has been employed will be found in Appendix No. 1.

Latitude and longitude of points in West Virginia.—To meet an application made at the approach of last winter by the chief engineer of the military department of West Virginia, the late Lieutenant J. R. Meigs, United States corps of engineers, the telegraphic method of determining longitude was applied by Assistant G. W. Dean, in connexion with the ordinary method of observing for the latitude at eleven stations in the department. Mr. Dean made his party arrangements at Clarksburg early in December, and then took charge of the operations requisite at Washington city, the purpose being to use the military telegraph lines, and to refer all the determinations to the station in that city. Sub-Assistant A. T. Mosman and Mr. S. H. Lyman were detailed with a sidereal chronometer and the eight-inch Gambey vertical circle No. 57 to observe at the western stations. Observations were begun on the 23d of December, and closed on the 24th of March.

In determining longitude, Assistant Dean used at Washington a mean time chronometer, of which the corrections and rate were obtained by comparison with the time of the Naval Observatory, by the kind permission of its superintendent, Captain Gillis, United States navy. On nights favorable for observing, if the line was at the same time available, the mean time chronometer was taken to the War Department, and signals were exchanged with the observer in West Virginia, the time of each being noted on the chronometers at both ends of the line. Mr. Dean was aided in these operations by Mr. P. H. Donegan. Seven signals thus made during a single minute at Washington were considered a series of comparisons. Signals were then made from the western station, and again from Washington, alternating until eight or ten series were successfully exchanged on the same night by the "eye and ear method." From subsequent comparison of

the times noted by the two chronometers, the longitude was deduced of the stations at Martinsburg, Clarksburg, Cumberland, Grafton, Cameron, Wheeling, Parkersburg, Point Pleasant, South Point, (Ohio,) Gauley Bridge, and Charleston. The exchange of time signals by telegraph was hindered at several of the stations, and prevented entirely at Charleston by the movements of guerilla parties. Mr. Mosman determined the local time at the western stations by two hundred and eighty observations on twenty standard stars.

At all the stations already named the latitude was determined from one hundred and twenty-five observations on eleven stars. These determinations of geographical position, although not possessing the accuracy of those made in connexion with the geodetic operations of the Coast Survey, supply a far closer approximation to the true relative positions of the stations than was previously known, and greatly assisted in the adjustment of the old county maps and recent military surveys, so as to form an improved map of the department.

Lieutenant Meigs furnished transportation for the party and instruments. The operations were facilitated also by the obliging courtesy of Major Eckert, superintendent of the military telegraph lines at Washington.

The records of these observations have been received at the office in duplicate as usual, and the reductions for latitude and longitude have been completed, and applied in correcting the map of the military department.

Assistant Dean during the summer and autumn was on duty with my field party in Section II. On closing the work in Virginia, Sub-Assistant Mosman was assigned to duty in Section I.

Magnetic observations.—While he was engaged with the party in the determination of geographical positions in West Virginia, Mr. Lyman observed the approximate declination of the magnetic needle at the principal stations, using the declinometer D. 22. The instrument was generally adjusted in the open air, and the direction of the suspended magnet was noted at intervals of a few minutes during an hour or more.

From the unusual severity of the winter, and the exposure to which the party was necessarily subjected in passing from station to station, and in night observations, the health of Mr. Lyman became so seriously impaired as to induce his resignation.

Topography of the environs of Baltimore, Maryland.—The plane-table survey of the ground commanded by the defences erected last year in the vicinity of Baltimore was continued during the winter by two parties. Sub-Assistant C. T. Iardella succeeded Sub-Assistant Donn in November, and Assistant C. M. Bache was assigned early in January. Both parties have continued the detailed survey under the direction of Colonel W. F. Reynolds and other officers who successively filled the position of chief engineer of the middle department. Mr. Iardella executed the topography eastward of Jones's falls from the city to Cross Keys village, and thence in a circuit towards the Baltimore and Philadelphia railroad. The circuit westward of Jones's falls was surveyed by Assistant Bache as far as the Franklin turnpike, where he joined with the plane-table work done last year by Sub-Assistant Donn in the western approach to the city.

Sub-Assistant Iardella is still engaged in the field. During part of the season he was aided by Mr. H. W. Bache. The occupation of Mr. Donn in the present season will be stated elsewhere in this section, and under the head of Section VIII. Assistant Bache continued the survey near Baltimore until September, and was then assigned to duty in Section II. In the early part of the season he was aided by Mr. Charles S. Hein. The following are the statistics of the survey of the environs of Baltimore :

Roads surveyed.....	96 $\frac{1}{4}$ miles.
Streams surveyed.....	77 $\frac{3}{4}$ "
Area of topography, (square miles).....	20 $\frac{1}{2}$

Sub-Assistant Donn being incidentally in Baltimore during the rebel raid in the early part of July, promptly reported to the military authorities for such service, if needed, as he had rendered last year at the time of the invasion of Maryland by the rebel forces under General Lee.

Topography near Washington, D. C.—Sub-Assistant Charles Ferguson was employed between the 10th of December, 1863, and the 20th of March following, in extending the topographical survey along the north-east line of the District of Columbia. This work was done at the request of the engineer of defences. It adds a breadth of about three miles to the District map along that boundary. About half of the additional area had been previously mapped. The Upper Marlboro' and Long Old Fields roads appear on the sheet of Mr. Ferguson, and the creeks known as Cabin Branch and Beaver Dam branch of the Potomac, and the southwest branch of the Patuxent.

The statistics of the work are as follows :

Roads surveyed.....	32 miles.
Creeks surveyed.....	25 "
Area, (square miles).....	15

Mr. Ferguson was employed during the summer in Section I.

Topography of Arlington Heights, Virginia.—By request of the Quartermaster General in June, a minute plane-table survey has been made of the Arlington estate, comprising two hundred and fifty acres, with reference to the use of the ground as a national cemetery. Contour lines were traced on the map corresponding to successive elevations of five feet. The lines run with the level for this purpose make an aggregate of twenty-eight miles, and determine the height of the ground at three thousand points.

This survey was made by Mr. E. Hergesheimer, assisted by Mr. R. E. McMath, with a working party detailed from the 169th regiment of Ohio militia. The map was drawn at the office on the desired scale by Mr. Hergesheimer, and photographed copies of it have been furnished to General Meigs. Mr. McMath had been previously on duty in Section VI. The remaining part of the summer and autumn was occupied in Section I.

Reconnaissance duty in the James river campaign, Virginia.—After leaving Section VIII, Assistant P. C. F. West rejoined the command of Major General W. F. Smith at Yorktown in March, and remained with the staff, in which service he ranked as captain, until the 14th of June. He accompanied General Heckman on a reconnaissance towards Port Walthall, which ended in a brisk engagement. Next day Captain West was sent with a small detachment, but falling in with the reserve of the rebel army returned to camp. During the battle at Swift creek he was on duty with the staff of General Martindale. Besides the duties of reconnaissance he was actively engaged in the battle at Kingsland's creek, and in all the actions prior to it, in the vicinity of Bermuda Hundred.

When Major General Smith moved his command to the head of York river, Captain West was sent with twenty men up the south bank of the Pamunky, and opened communications with the army of Lieutenant General Grant, then on its march southward. He took part in both of the battles at Cold Harbor, and remained on the staff of General Smith until the command was again transferred to the banks of the James river.

Assistant West has now served three years with the army, and being active in the front, he has participated in more than twenty battles. The approach of summer bringing the return of symptoms which had before prostrated him by severe illness, Mr. West returned north and passed the remainder of the season in topographical duty, which has been mentioned under the head of Section I. Major General Smith has borne ample testimony as to his gallantry in action, and in regard to his usefulness in the command in surveying and engineer duty.

Surveys at Bermuda Hundred, Virginia.—At the request of the chief engineer of the military department of Virginia and North Carolina, Sub-Assistant J. W. Donn was assigned to duty in April. He accompanied the army of Major General Butler in the movement on Bermuda Hundred, and made special surveys at Fort Powhatan, Wilson's Wharf, and Deep Bottom. Very important additions were made to our military map of southeastern Virginia from the material which he collected and forwarded to the office. Mr. Donn continued in service under the orders of Brigadier General Weitzel until the 10th of September. He was aided in topographical duty during July and August by Mr. H. L. Marindin.

Service with military forces in Virginia.—At the end of October, 1863, Sub-Assistant Cleveland Rockwell reported to Major General Foster at Fortress Monroe. This was just previous to the transfer of that officer to Knoxville, Tennessee. Major General Butler, on taking command at Fortress Monroe, requested the services of Mr. Rockwell for the survey of a depot for prisoners at Sewall's Point, and that duty was completed without delay. Mr. Rockwell then started for the west, and leaving Cincinnati at the close of November, reported as soon as possible at Knoxville. His service in that vicinity will be referred to under the head of Section VIII.

Under orders from Major General Franklin, Assistant J. G. Oltmanns joined the army in the Shenandoah valley on the 16th of September last, and reported for topographical service to Brevet Major General Emory. In the battle of the 19th, at Winchester, he served on the staff, and in the same capacity in the battle at Fisher's Hill on the 23d. The last-named position he mapped for the use of the commanding general.

Mr. Oltmanns accompanied the army in the rapid movement up the Shenandoah valley to Mount Crawford, and assisted in repairing bridges to further the advance. On the return he performed reconnaissance duty, and after the memorable battles at Cedar Creek and Middletown, in both of which he was actively engaged, made a detailed sketch of the country from Middletown to Strasburg, to show the movements of the 19th army corps and the approaches to the rebel positions. He is now at work on a survey of the encamped ground of the army on Opequan creek.

The field-service of Assistant Oltmanns preceding the duty here alluded to will be mentioned under the head of Section VIII.

Military map of West Virginia.—At the request of the chief engineer of the military department of West Virginia, the late Lieutenant Meigs, I detailed Mr. A. Lindenkohl from the office early in October, 1863, to assist in compiling the data which had been collected at Clarksburg, from the army surveys and by expeditions of the cavalry forces. Other material procured from the records of surveys at Annapolis and Baltimore, and from the Engineer Bureau, was made auxiliary to the preparation of a military map of the department. Mr. Lindenkohl assisted also in the construction of a large map of the environs of Cumberland, and computed the latitude of a number of places in the State from sextant observations by Lieutenant Meigs. He was employed in West Virginia until the 16th of February, and then returned to duty in the Drawing Division of the office.

Hydrographic survey of Trent's Reach (James river, Virginia.)—This was the first service rendered by Sub-Assistant J. S. Bradford after joining the staff of Admiral Lee, in June. The soundings, about two thousand in number, were completed on the 14th of the month, and embraced the bar and the entire expansion of the river on the south side of Farrar island. The battery at Howlett's being evacuated by the enemy on the morning of the 14th, Mr. Bradford took advantage of their absence and sounded the upper part of the reach as far as the upper wharf, from which he had been several times fired upon previously. This service proved to be timely, as the rebel forces reoccupied the battery in the evening, a few hours after Mr. Bradford had examined the ground, with the intention of making a close survey of the site. Soon after, the use of obstructions in Trent's reach having been decided upon, Mr. Bradford was called on to determine the line which they were to occupy. When the work thus marked out was completed the entire line was designated on his chart, and copies of the sheet were furnished for the use of the squadron. The party was repeatedly fired on from the battery at Howlett's while engaged in locating the line.

Sub-Assistant Bradford remained on duty with the flag-ship in James river until the third of July. The remainder of the month, excepting a few days, was passed at Hampton Roads in preparing charts for the use of the blockading fleet off Wilmington, and for the Navy Department. During this time Mr. Bradford visited Trent's reach twice under the orders of the admiral, on duty connected with the line of obstructions. His subsequent service with the North Atlantic blockading squadron will be stated under the head of Section IV.

Tidal observations.—The tidal observations at Old Point Comfort, Virginia, were continued in charge of Mr. M. C. King until March 1st, when he resigned. The station was then intrusted to Ordnance Sergeant C. Kelly., United States army, who has continued the observations to this time successfully.

SECTION IV.

FROM CAPE HENRY TO CAPE FEAR, INCLUDING THE COAST OF PART OF VIRGINIA AND OF PART OF NORTH CAROLINA.

The operations to be described under this head were carried on by parties assigned to work under the orders of Admiral S. P. Lee when in command of the North Atlantic blockading squadron. One of the parties remained during the entire year on duty with the squadron, and is now engaged under the orders of Admiral Porter. An abstract of the parties and operations is given in Appendix No. 1. It will be seen that the results obtained fall in with the regular working of the survey.

Survey of Roanoke river, North Carolina.—This survey, as well as others to be noticed presently, was made at the special request of the flag officer of the North Atlantic blockading squadron, Admiral S. P. Lee. It includes the river and its shores to Ryan's Thoroughfare, above Plymouth, North Carolina, and below to its mouth in Albemarle sound.

Sub-Assistant R. E. Halter reported on the flag-ship at Hampton Roads on the 12th of November, 1863. Under directions then received he applied to the senior naval officer at Newbern, and was assigned to quarters on the gunboat Seymour. On the 23d a base line was measured above Plymouth, and triangulation made in connexion with it. The work was then pushed on, subject only to interruptions caused by frequent attacks from small parties of the rebel forces. Mr. Halter completed the triangulation and the topography by the end of January.

The Roanoke river below Ryan's Thoroughfare was sounded by Sub-Assistant J. S. Bradford and his aids, Messrs. H. M. De Wees and H. L. Mariudin. Batchelor's bay was included, and the water passages known as Middle and Eastmost rivers. This work was done with a boat from the steamer Seymour, and under many disadvantages, the vessel being often needed for picket duty and for delivering despatches. Mr. Bradford completed soundings in this vicinity on the 10th of February. The statistics are thus stated in his report:

Miles run in sounding.....	195
Angles measured.....	839
Number of soundings.....	13,451

Topography of Roanoke island, North Carolina.—The survey of Roanoke island was in progress in the spring of 1861, and would have been completed before the ensuing summer, but the instruments there in use were seized and kept by persons acting under the State authorities of North Carolina, as mentioned in my report of that year.

While engaged in the vicinity this season Sub-Assistant Halter found means to complete the topography of the south end of the island. The work is in detail, and, like all the field-work of the present season in this section, is conformable in character to the regular operations of the survey of the coast.

Survey of Croatan sound, North Carolina.—Sub-Assistant Halter took up this work on the 20th of February, but its progress was much hindered by bad weather. Field-work, including the triangulation and shore-line survey, was finally closed on the 26th of May. In the interval, the steamer Seymour was frequently on naval duty, and part of the time was employed to watch the rebel movements in Roanoke river. On such occasions Sub-Assistant Halter continued on service with the vessel. While in the vicinity Mr. Halter took the opportunity to visit the site of the primary base line on Bodie's island. The marks at the ends of the line were found readily, as were also several of the adjacent stations used in the main triangulation of the coast of North Carolina. The following summary comprises the statistics of field-work on Roanoke river and Croatan sound:

Signals erected.....	73
Stations occupied.....	48
Angles measured.....	176
Number of observations.....	373
Shore-line surveyed, (miles).....	51

During the summer and autumn Sub-Assistant Halter was on duty with the party of the superintendent in Section II.

Admiral Lee has expressed in written communications a high sense of the value of the services rendered by the parties attached to his squadron. By direction of the flag-officer the obstructions placed by the enemy in Croatan sound at the outset of the war were examined in February by Sub-Assistant Bradford. At several intervals, permitted by the exigencies of the naval service in the succeeding months closing with May, the hydrography of the sound was developed and its channel marked by buoys from Roanoke marshes to Croatan light, the soundings being extended as far up as Pork Point. This was a work of much necessity, vessels of the squadron having frequently grounded in going through the sound. Both lines of obstructions put down by the enemy have been carefully marked on the chart. The statistics of the work are as follows:

Miles run in sounding.....	208
Angles.....	1,486
Number of soundings.....	23,664

The difficulties that multiplied in the way by the frequent withdrawal of the steamer for naval service were in part relieved by the interest taken in the work by Mr. Newton Eggleston, acting second assistant engineer of the Seymour, and by Mr. George Doten, purser's steward. Both served as recorders in the hydrographic party whenever their regular duties would permit.

After leaving this section, Sub-Assistant Bradford continued on active duty in Section III on the flagship of Admiral Lee, but returned in September with a vessel specially assigned for use in prosecuting hydrography. His subsequent work will be mentioned presently. The vessels detailed to attack the rebel ram Albemarle were piloted through Croatan sound by the hydrographic party in the Seymour.

Triangulation of Neuse river, North Carolina.—A party organized under the charge of Assistant G. A. Fairfield for continuing the preliminary survey of the Neuse river was at New Bern on the 4th of December last, fully prepared for resuming work. At that time a large band of guerillas was making incursions along the lower part of the river, rendering it unsafe to use the schooner James Hall, which was to serve for transportation. The convoy of a gunboat was promptly tendered by the senior naval officer, Commander Davenport, but the early opening of the military campaign by the rebel forces in the vicinity of New Bern made it frequently necessary to withdraw the protecting vessel for naval service. After repeated attempts the work was resumed on the 25th of February, when hostile movements in the waters of North Carolina called for full activity in the naval squadron and for vigilance in those having the care of transport and

other vessels. Under these circumstances Assistant Fairfield worked several days at a new station in the triangulation of the Neuse river, and then assisted with his vessel in meeting a call made by Admiral Lee for a resurvey of Hatteras inlet. He was aided in this section by Mr. Horace Anderson. The party and vessel were employed during the summer in Section I.

Hydrography of Neuse river, North Carolina.—This work was commenced on the 1st of January by the party of Acting Assistant Alexander Strausz, and arrangements were made at the same time for running the shore line of the river below New Bern. Good progress during the month had extended the soundings as far down as the lower blockade. New Bern was attacked by the enemy on the 1st of February. The work was at once discontinued. Mr. Strausz, with his aids, Messrs. H. G. Ogden and Gershom Bradford, tendered themselves for naval duty on board of the gunboat Commodore Hull, as aids to perform watch duty, and the offer was accepted. Mr. Strausz, knowing the channel, set three buoys for leading up or down the river, and piloted one of the army transports by the nearest route of communication between Fort Anderson and Fort Chase. At the request of General Peck he also made a reconnaissance of Batchelor's creek with armed boats detailed for that service by Commander Davenport. Defensive operations in the vicinity of New Bern occupied the party until the 1st of March.

Resurvey of Hatteras inlet, North Carolina.—This work was done at the request of Admiral Lee. No other vessel being then available, Mr. Strausz used the surveying schooner James Hall, belonging to the party of Assistant Fairfield. The month of March was occupied in running soundings to determine the hydrographic changes and in tracing the shore-lines of the inlet. Buoys were then set to mark the new channel—three in the swash and a first-class can-buoy in Pamlico sound. The swash buoys being carried away by heavy gales in April, were replaced after a careful re-examination of the channel.

Of the changes observed at Hatteras Mr. Strausz remarks: "The channel now used over the swash is entirely different from that shown on the chart of 1861. The new one has opened since December, 1863. The depth of water over the new swash at mean low tide is a little over seven feet—the mean rise and fall being one foot and two-tenths."

The following is a summary of statistics taken from the reports of Mr. Strausz:

Miles run in sounding.....	91
Angles.....	808
Number of soundings.....	6,040
Tidal stations occupied.....	3
Shore-line traced, (miles).....	40

Mr. Strausz remained in service in the waters of North Carolina until the end of May, and was subsequently employed in Sections I and II. Mr. Ogden, of his party, has since been on duty in Section II, and Mr. Bradford in Section V.

Hatteras inlet was re-examined in the latter part of September by Acting Assistant Edward Cordell. The changes then observed required a removal of the buoys. The channel to the westward of the Middle Ground was found to be filled up, and the west breakers extended across it nearly to the buoy which marks the eastern extremity of the Middle Ground. The main channel had deepened to eighteen feet at low water, (spring tide,) with lines of continuous breakers on either side of it. The changes reported by Mr. Cordell were illustrated by a sketch of soundings. These appear in the new edition of the preliminary chart of Hatteras inlet which was issued from the office in October.

Resurvey of Beaufort Harbor entrance, North Carolina.—For this service Acting Assistant Edward Cordell reported to Admiral Lee at Fortress Monroe on the 25th of March, and was assigned to duty under the immediate orders of Captain Dove at Beaufort, North Carolina, on the 30th. A small vessel belonging to the blockading squadron being assigned for the use of the hydrographic party, Mr. Cordell at once commenced a resurvey of the bar and of the channel leading into the harbor. "The principal changes in the channel occur at black buoy No. 3. In 1862 it was placed in twenty feet of water to mark the point of the southwest breakers. Since then the breakers have extended westward about a hundred yards beyond the first position of the buoy, and but eight feet of water was found at its position. It was removed into sixteen feet water." Other changes of depth are stated in Mr. Cordell's report. (Appendix No. 6.)

Messrs. A. M. Wetherill, Jas. W. Brown, and Franklin Platt aided in this resurvey. The work was completed on the 2d of May, and a new edition of the chart furnished from the office, with revised sailing directions for the use of the blockading squadron.

The statistics of the resurvey at Beaufort entrance are as follows:

Miles run in sounding.....	137
Angles observed.....	2, 037
Number of soundings.....	11, 959

The buoys were re-set so as to mark the line of best water as developed by the resurvey.

In the latter part of December the channel into Beaufort had been examined by Acting Assistant Alexander Strausz. A report on its course, direction, and depth of water was, at the same time, forwarded to the flag-officer, with tracings from the chart then made.

Hydrography of Core sound, North Carolina.—In connexion with the work mentioned under the last head, Mr. Cordell during the summer sounded out the channel which leads from Bogue sound through the straits into Core sound, and extended the inside hydrography as far as Harbor island, including also the waters of Beaufort harbor, North Carolina. This survey shows that the channel of Core sound gives only five feet at the shoal places. The channel was marked by the party with three iron can buoys and one hundred and thirty-five stakes. The particulars developed by the soundings are stated in the Appendix, (No. 7.)

Messrs. Wetherill and Platt served in the party as aids.

In addition to hydrographic service, Mr. Cordell, throughout the entire season, performed the duties of acting light-house inspector, and reported regularly to the chairman of the board.

The results of the work in Core sound, which was completed by the 9th of September, are shown on Sketch No. 24.

Hydrographic reconnaissance of the Cape Lookout shoals, North Carolina.—The Cape Lookout shoals were examined in August last by Lieutenant Commander T. S. Phelps, United States navy, Assistant Coast Survey. Sketch No. 25 shows the results of this reconnaissance. Three shoals, probably parts of the same ridge, were found, one extending S. by E. $\frac{1}{4}$ E. from the south point of the constant breaker, three miles to seaward, or ten and a half miles from the light-house. The bottom here is quite uneven, the depth on the shoal lumps varying from about nine feet to eighteen feet. About a mile and a half to the southward and eastward the soundings gave five and a half fathoms, and further still in the same direction, or SE. by S. $\frac{1}{2}$ S., thirteen and a half miles from the light-house, five and a quarter fathoms were found. The examination developed no indication of shoal ground at present outside of the last-named limit.

The report made by Lieutenant Commander Phelps is given in the Appendix, (No. 5.)

The statistics are thus reported :

Angles determined.....	45
Miles run in sounding.....	166
Number of soundings.....	1, 665

The steamer Corwin and party of Lieutenant Commander Phelps were subsequently employed in the vicinity of Portland entrance, as was stated under the head of Section I.

Hydrography of Bogue sound, North Carolina.—This work was commenced in August, under the orders of Admiral Lee, by Sub-Assistant Bradford, who had served on his staff during the summer. The steamer Nansemond, then awaiting the completion of a new boiler, was assigned for temporary service in the hydrography, but her draught made it impracticable to take that vessel higher up than Carolina city. Good progress was made, however, with the prospect of early completion, but not before the steamer was called to Baltimore to receive the boiler. By direction of the Admiral, Mr. Bradford went in the vessel to expedite the repairs of the steamer Seymour, which had been in general use for hydrographic purposes in this section. Mr. H. M. De Wees joined the party as aid at Hampton Roads, and accompanied Mr. Bradford to Beaufort, North Carolina, where he arrived on the 27th of September. The succeeding fortnight was employed in preparing charts for the use of the naval forces in the projected attack on Wilmington. In addition to the Coast Survey data these contain all the information gained by reconnaissance in reference to the number and strength of the enemy's works, and views of the coast, and of the defences taken from different points of observation. The new charts were delivered to Admiral Lee just previous to the transfer of the command of the North Atlantic squadron to Admiral Porter. At the request of the last-named officer Sub-Assistant Bradford joined his flag-ship, and is now on duty with the squadron. He reports the following statistics of the partial survey of Bogue sound, which work he expects to complete hereafter :

Angles measured.....	918
Number of soundings.....	10, 049

SECTION V.

FROM CAPE FEAR TO ST. MARY'S RIVER, INCLUDING PART OF THE COAST OF NORTH CAROLINA AND THE COAST OF SOUTH CAROLINA AND GEORGIA.

The parties on the coast of South Carolina and Georgia, while prosecuting the regular work of the survey, when practicable, also rendered incidental service in piloting vessels of the South Atlantic blockading squadron. Besides the surveys made at the request of Admiral Dahlgren, the parties were kept in readiness for reconnaissances in co-operation with the forces of Major General Foster. A summary given in Appendix No. 1 shows the number of parties and the localities of work. In this chapter the operations will be, as usual, referred to under separate heads.

Resurvey of Charleston bar, South Carolina.—Assistant W. S. Edwards reached Port Royal with the schooner *Bailey*, on the 7th of October, 1863, and, under the orders of Admiral Dahlgren, a few days after commenced the resurvey of the bar at Charleston entrance. His soundings were made chiefly in what is known as the "Pumpkin Hill channel." The results gave a depth of twelve and a half feet at mean low water, the course in being due west, (magnetic.) Buoys were set at once by the light-house inspector conformable to the soundings. Mr. Edwards replaced the outer swash channel buoy to guide the blockading vessels, and also determined the positions of some of the buoys and obstructions in Charleston inner harbor. His party was employed until the 1st of February, when Assistant C. O. Boutelle took charge of the work, Assistant Edwards being then under orders for service on the western coast. He was aided at Charleston bar by Messrs. F. H. Dietz and L. A. Sengteller.

The acquaintance of Mr. Edwards with localities in the vicinity of Charleston was made available in verifying accounts brought by deserters from the rebel lines.

Assistant Boutelle, on arriving at the bar, made a careful study of the results given by the soundings, and prepared sailing directions to meet the changes. He also reset the buoys to the best advantage. Remarkable changes were noticed at the bar. A shoal exists now where the hulks were sunk in 1861, and on either side of it a channel with eleven feet, the depth of that in which the obstructions were placed. The Lawford channel has closed entirely, and in lieu of it there is shoal ground having only four feet of water.

Shore-line survey of Morris and Folly islands, South Carolina.—Sub-Assistant W. H. Dennis, with his party, in the schooner *Caswell*, reached Port Royal on the 20th of February. Preparations were then on foot for an expedition from Jacksonville, Florida. Mr. Dennis had taken up plane-table work at Port Royal, and was about a week so engaged, when request was made by Major General Gillmore that he should assist with the command of General Seymour in Florida. The *Caswell* sailed on the 28th. Mention will be made presently of the occupation of the party in the lower section of the coast. Mr. Dennis returned to Port Royal on the 23d of May, and made for Admiral Dahlgren a survey of the shore-line of Morris and Folly islands, and of the inland passage between Light-house inlet and Folly river. The positions of batteries were also determined and marked on maps.

The statistics of these surveys are thus given in the field report:

Shore-line surveyed.....	17½ miles.
Creeks	12 "
Marsh line	5½ "
Area surveyed, (square miles)	2

Major General Foster ordered all conveniences needed by the party, and was furnished with copies of the maps.

Topography of Bay Point and Land's End, (Port Royal, South Carolina.)—While at Port Royal, in the latter part of May, Mr. Dennis made a survey, on a large scale, of Bay Point and Land's End, embracing the details within an area of about two square miles. Seven miles of shore-line were traced and marked.

This survey was made at the request of Admiral Dahlgren. The work had been commenced by Mr. W. W. Harding, of the party of Assistant Boutelle, just previous to the arrival of Mr. Dennis.

Hydrography of Light-house inlet and Folly river, South Carolina.—Sub-Assistant F. P. Webber took charge of the schooner *Bailey* after the departure of Assistant Edwards, and, under the direction of Assistant Boutelle, sounded out Light-house inlet from the bar inwards as far as the obstructions. He also completed the sounding of Folly river, joining his work with that done in 1862.

A chart containing the results of these surveys has been issued from the office. The soundings were completed in March.

Sub-Assistant Webber continued in service at Port Royal until June, and then took up duty in Section I. Mr. J. A. Guldin aided him in duty on the coast of South Carolina.

Service at Port Royal, South Carolina.—Assistant Boutelle placed the buoys needed in Port Royal harbor, and personally supervised the raising of the back beacon on Hilton Head. The cutting needed for bringing the beacons into view was marked out by his party.

On the 19th of March the steamer *Vixen* went up Beaufort river, and, taking the inland passage, conducted the gunboat *Hale* through into St. Helena sound. In May the party set two first-class buoys on the bar at Port Royal to replace those which had been carried away by storms.

Mr. Boutelle subsequently accompanied the naval expedition up the South Edisto river, the design of which was to co-operate with a movement of the land forces.

A revised edition of the chart of Beaufort river, South Carolina, accompanies this report as Sketch No. 26.

Hydrography of the approaches to Wassaw sound, Georgia.—The part of this work remaining to be done outside of the entrance was taken up by the party of Assistant Boutelle in September, and completed in November. The hydrography now includes the northeastern approach to the bar, and in that direction the soundings made partly with the steamer *Vixen* and partly with the steamer *Bibb* are connected with the survey of Savannah river entrance. During the temporary absence of Mr. Boutelle from the section the work was conducted by Acting Master Platt, the executive officer of the steamer *Bibb*. In preliminary form the results are shown on Sketch No. 27.

Tidal observations.—A self-registering tide-gauge was set up at the wharf at Bay Point, Port Royal sound, by Assistant Boutelle, and observations were begun August 22. The position being, however, too much exposed, the record was frequently interrupted, and the gauge will be removed to a more sheltered locality.

The observations made last year at the light-ship on Martin's Industry shoal with the pressure tide-gauge have been compared in the office with those made simultaneously on shore. The comparison was quite favorable. Twenty-eight high waters and twenty-nine low waters were observed at both places, and gave a probable error of twelve minutes in the times and 0.2 foot in the heights for the difference of a single observation from the mean.

SECTION VI.

FROM ST. MARY'S RIVER TO ST. JOSEPH'S BAY, INCLUDING THE EASTERN AND PART OF THE WESTERN COAST OF FLORIDA, WITH THE FLORIDA REEFS AND KEYS.

The work of the season in this section was confined to the upper part of the eastern coast of Florida, and principally to the St. John's river. As in many other instances, the topography and hydrography executed, though availing as work done in the regular progress of the survey, was of special interest at a juncture in military and naval operations. Appendix No. 1 contains a summary of the work, which will be now referred to in more detail.

Topography near Jacksonville, Florida.—Sub Assistant Dennis reported to Brigadier General Seymour, at Jacksonville, early in March, and on the invitation of that officer joined his staff and went with the expedition to Pilatka. There he surveyed all the ground held by the government forces, and assisted in laying out the line of defences. The aid of the party, Mr. S. P. Holt, in the schooner *Caswell*, had been meanwhile employed in extending the survey about Jacksonville. Mr. Dennis rejoined the party on the 23d of March, and continued plane-table work until the 23d of May, when the area deemed important for defensive purposes had been mapped. In connexion with this duty he made, at the request of General Birney, a reconnaissance of the roads leading from Jacksonville to St. Augustine, to Picolata, and to Mayport Mills. After being relieved from service in the St. John's river, the *Caswell* returned to Port Royal, as already stated.

Assistant Boutelle was furnished by this party with the results of a shore-line survey of the mouth of the St. John's river. While engaged in the reconnaissance referred to, Sub-Assistant Dennis traced one hundred and seventeen miles of road. The statistics of the detailed surveys are as follows:

Shore-line.....	7½ miles.
Roads.....	44½ "
Creeks.....	9 "
Marsh-line.....	13½ "
Area surveyed, (square miles).....	9½

The field sheets of this work have been inked, and are now at the office. Mr. Dennis returned with his

party to New York on the 30th of June, and then took up plane-table duty in Section I, as mentioned under that head. His services in Florida have been fully acknowledged in a communication from General Seymour. Mr. Dennis, while mapping ground beyond the picket-lines at Pilatka, twice barely escaped capture. His vessel, the schooner Caswell, was in tow behind the United States steamer Harriet A. Weed, when that vessel was totally destroyed by the explosion of a rebel torpedo on the 9th of May, in St. John's river.

Service with the direct tax commission in Florida.—The request made at the close of last season by the chairman, that the services of a topographer should be continued during the stay of the commissioners in Florida, was met by the assignment of Mr. R. E. McMath in March. Under instructions given by the chairman at Fernandina, Mr. McMath proceeded to St. Augustine, and there constructed a map of Nassau county, showing the land sections, their numbers, subdivisions, contents, and other particulars, as developed by the township plats of the United States land surveys. He also made a tracing from the map of Duval county, containing roads and other features additional to those in existence when the map was constructed. Through Sub-Assistant Dennis this tracing was transmitted to Brigadier General Gordon, that officer being then in command of the military forces at Jacksonville.

Before returning from this section, Mr. McMath compiled and sent to the office a sheet showing on a reduced scale the four counties adjacent to the lower part of the St. John's river. This with other material was used for the issue of an improved map of the northern part of Florida, from the office in June.

The occupation of Mr. McMath during summer and autumn has been referred to under the heads of Section I and Section III.

Hydrography of the St. John's river, Florida.—The surveying steamer *Vixen*, with the party of Assistant Boutelle, accompanied the naval and military expedition that went up the St. John's river in February. Acting Master Platt buoyed out a new channel for entering, which had opened to the southward of the old channel. Mr. Boutelle had previously marked the bar. He subsequently adjusted signal lanterns, so that vessels might cross at the night tides. Mr. Platt took in the steamer Mahaska, and was followed by Mr. Harding with the *Dai Ching*. The party then went to the assistance of the Ben Deford, army steamer, that vessel having grounded, and piloted her into the channel. On the way up to Jacksonville the channel was marked by the party in the *Vixen*, and signals were at the same time erected for a new hydrographic survey, to extend, if practicable, from the bar to a point five miles above the town. This resurvey was specially requested by Admiral Dahlgren, as, owing to natural changes, vessels belonging to the naval and transport service had much difficulty in getting up to Jacksonville after crossing the bar. While sounding, Assistant Boutelle went to the assistance of the Pawnee, and the service of his party in getting her afloat was duly acknowledged by Captain Balch. The hydrography was pushed at intervals under many disadvantages, and was finally concluded in May at Mayport Mills.

Mr. Boutelle gave personal attention to the placing of beacon-lights at the mouth of the St. John's river, and for that and other service was in communication with the officers of the Light-house Board.

Messrs. W. W. Harding, A. R. Fauntleroy, L. L. Nicholson, and C. P. Dillaway served as aids in the hydrographic party.

The *Vixen* was brought down the St. John's river soon after the disaster which met the army boat H. A. Weed. Acting Master Platt, of the party of Assistant Boutelle, noticing slight ripples on the water, and supposing them to be caused by torpedoes, was sent to examine the place. He succeeded in bringing up one of six, and it was delivered to Admiral Dahlgren. The positions of the others were pointed out to the picket-boats, and notified also to Captain Balch, of the Pawnee.

Magnetic observations at Key West.—These have been continued throughout the year in charge of Mr. Samuel Walker. The original photographic traces of the three instruments and their hourly measures are preserved in the archives for future discussion. The series of observations now extends over a period of four years and a half. It is designed to include, in all, one-half of the eleven-year period in the secular variation.

SECTIONS VII, VIII, IX.

FROM ST. JOSEPH'S BAY, FLORIDA, WESTWARD TO THE RIO GRANDE, INCLUDING PART OF THE WESTERN COAST OF FLORIDA, AND THE COAST OF ALABAMA, MISSISSIPPI, LOUISIANA, AND TEXAS.

Including some reconnaissance duty on the coast of Texas, all the work to be described under this head was in connexion with military or naval operations. Two parties were engaged for the army of the Ohio; four for the army of the Cumberland; two for the Mississippi squadron and army of the Tennessee, and two

served with the army of the Gulf. Appendix No. I shows in tabular form the character of the service in each locality. The work of each party will be now described.

Topographical survey of the vicinity of Knoxville, Tennessee.—Major General Foster having requested the detail of two officers of the Coast Survey for service with his command in East Tennessee, Sub-Assistant Rockwell and Mr. R. H. Talcott were directed to report at Cincinnati in the latter part of November, 1863. After a toilsome journey by way of the Cumberland Gap, the party reached Knoxville with their instruments on the 11th of December. Next day, under the immediate orders of Captain O. M. Poe, then chief engineer in the department of the Ohio, a plane-table survey was begun of all the grounds of approach towards Knoxville. A base line of about fifteen hundred metres was measured, and signals were set up and determined in position by means of the plane table. The area to be included lay on both sides of the Holston river. Mr. Rockwell took the north side, and his survey was made to include the city of Knoxville and the heavy fortifications, with the contour of the ground which they commanded. Mr. Talcott surveyed the southern approaches, which are more hilly, and quite thickly wooded. One peculiarity of the region under notice is the numerous "sink holes" through which the smaller streams disappear suddenly, to the surprise of the topographer.

The map of the survey around Knoxville comprises about thirteen square miles. The part assigned to Mr. Talcott being complete in the middle of February, he was detached by General Foster, and after turning in his plane-table sheet at the office he retired from the service, with the cordial esteem that had been won by his abilities and genial disposition. Sub-Assistant Rockwell remained in the department of the Ohio until relieved from duty by Major General Schofield on the 2d of June.

Several copies of the map of the vicinity of Knoxville were made by Mr. Rockwell, and furnished to commanders of different branches of the military service at that post.

Topographical survey of Strawberry Plains, Tennessee.—Sub-Assistant Rockwell was employed in April and May with a plane-table survey of Strawberry Plains. When the field-work was complete, the original sheet was inked and sent to the office of the adjutant general, at Knoxville.

Topography of the vicinity of Nashville, Tennessee.—When the headquarters of the military division of the Mississippi were removed to Nashville, Sub-Assistants F. W. Dorr and J. W. Donn were directed to make a topographical survey of its vicinity. Before taking up this work, Mr. Donn, under the orders of Major General Smith, examined the various branches that fall into the Cumberland river from the south between Nashville and the South Fork. This was for the purpose of finding a nearer route than the one which had been used for supplying the army at Knoxville. A detailed report of the reconnaissance was addressed to General Smith. At his return Sub-Assistant Donn took up the survey on the north side of Nashville, Mr. Dorr at the same time being engaged in mapping the southern approaches and the environs of the city, which service he commenced on the 3d of February. He was joined by Mr. Donn on the 22d, and working jointly the survey was concluded by the 18th of March.

Sub-Assistant Dorr was during the summer engaged in topographical duty in Section I, and Mr. Donn in connexion with the military forces near Petersburg, Va., as stated under the head of Section III.

The following are statistics of the survey at Nashville :

Roads traced	92½ miles.
Creeks	50½ "
River shore-line	20 "
Area surveyed, (square miles)	23

Topography of Chattanooga, Tennessee.—Previous to the forward movement of the army from its base at Chattanooga, the ground occupied by the defences and the country adjacent were surveyed and carefully mapped by Sub-Assistant Dorr; Sub-Assistant Donn at the same time made a topographical survey of Moccasin Point and of Raccoon mountain, the valley to the eastward of it, and the Lookout mountain and valley. This work was completed at the end of December, and was undertaken at the request of the chief engineer of the army of the Cumberland, General W. F. Smith. Assistant P. C. F. West, on reporting to the chief engineer, was attached to his staff, and entered on the discharge of duties with which he had become familiar in previous campaigns with the same commander. He took part in the movement at Brown's ferry, examined the banks of the Tennessee river lower down, and by way of Kelly's Ferry gap extended his reconnaissance through the mountains to Whiteside. The ground between the North Chickamauga and Brown's ferry was also examined, the object being to find routes for concealing from the enemy the intended movement of troops and the use of pontoons. Captain West was present in the battles before Chattanooga

in November, and acted on the staff of General Smith in the pursuit of the enemy to Ringgold. His subsequent connexion with the same command has been referred to under the head of Section III.

The plane-table sheets of the survey made by Messrs. Dorr and Donn comprise the following statistics :

Roads surveyed	169½ miles.
Creeks	103¼ "
Area of topography, (square miles)	44½

About twenty-seven miles of the course of the Tennessee river are included on the two sheets. The survey was commenced in the latter part of October, and was completed in the middle of January. All the ground passed over by the two topographers is marked by contour lines on the map, indicating successive elevations of twenty feet.

Sub-Assistant Fendall also reported at Chattanooga in October. Being then under orders for duty with the Mississippi squadron, his stay was limited to the time sufficient to reconnoitre the country for a road across Raccoon mountain, from Kelly's ferry to Whiteside. After performing this service he proceeded to Vicksburg.

The journey of the parties assigned to service at Chattanooga was attended with unusual difficulties, arising in part from the scarcity of forage for the animals used in transportation, and partly from the almost impassable condition of the roads between Stevenson and the ground occupied by the army.

Survey of Chickamauga battle-ground, Georgia.—Sub-Assistant C. H. Boyd was detailed for field service in December, to meet an application from General W. L. Elliott, chief of cavalry in the army of the Cumberland. On reaching Chattanooga he reported to Major General Thomas, and was at once attached to the staff. In addition to the duties assigned at headquarters, Captain Boyd at the end of January commenced a triangulation of the country south of Chattanooga, to include the battle-ground of Chickamauga. A base was measured, and points were determined in the usual way by the theodolite at seventeen stations. A topographical survey being ordered by Major General Smith, chief engineer, that duty was taken up without delay. Mr. Boyd's plane-table sheet includes about fifty square miles, and takes in all the ground occupied by the contending forces at the battle of Chickamauga. On another topographical sheet he traced the defensive lines and works around Chattanooga, and drew range-marks for the chief of artillery.

These surveys and duties in the line of military service occupied the time of Captain Boyd until the end of July. He then reported to the office in Washington, and there deposited the notes of his field-work and the plane-table sheets referred to.

Service with the Mississippi squadron.—The party of Assistant F. H. Gerdes has now completed three successive terms of service under the orders of Admiral Porter. That of the present season includes several important surveys on the Mississippi, on the Ohio, and on Red river, which will be best described under separate heads.

After conferring personally with the flag-officer, in October, 1863, and leaving Sub-Assistant Clarence Fendall in the section, Mr. Gerdes returned to New York. He joined the squadron at Mound City at the end of January following, with two aids, Messrs. T. C. Bowie and J. B. Adamson. Sub-Assistant F. F. Nes was assigned to service with this party, but was compelled to return by serious illness contracted at Cairo.

Before taking up duty for the squadron, Mr. Fendall met the call of the chief engineer of the army at Chattanooga for topographical service, and reported to the admiral on the 14th of November.

Of the surveys made during the season terminating on the 1st of July, those on the Mississippi will be first mentioned.

Reconnaissance between Rodney and Palmyra bend.—The result of this reconnaissance is a map showing on a large scale about fifty miles of the course of the Mississippi, its main channels, shoals, bars, the single plantations on its banks, the distinction of woods and cultivated grounds, towns, hills, swamps, the landings, roads leading into the interior east and west, the usual crossing-places, and many other features. In this work the party of Assistant Gerdes was occupied four weeks during April and May. The map has been inked, and is now at the office in Washington. An engraved reduction of it is given with this report. (Sketches Nos. 29 and 30.)

Topographical and hydrographic survey at Grand Gulf, Mississippi.—For this survey Mr. Gerdes had the use of the armed steamer Curlew, and force sufficient to resist the attacks of guerilla parties that would otherwise have rendered it impracticable. The topographical sheet shows the rebel and national lines of fortification, the peaks and spurs of hills which mark the banks of the Mississippi at Grand Gulf, and all the

natural and artificial features in the vicinity of the town. The entire bend of the river was carefully sounded and permanent bench-marks were established for future reference. All the soundings taken were reduced to an approximate medium stage of the river, or about thirteen feet above the level of ordinary low water. This survey was commenced on the 15th of March, and completed on the 16th of April. The party while at work was frequently fired on by guerillas.

Survey at Vicksburg, Mississippi.—Before the close of the preceding season Sub-Assistant Fendall had nearly completed his survey of the approaches to Vicksburg. The supplementary work, then prevented by illness, was resumed in November, 1863. At the request of Admiral Porter a picket guard and transportation were furnished by General McPherson, and with these facilities the survey was finished on the 4th of December. More particular reference was made to this work in my report of last year. The map includes not only the river defences, but also the rebel lines of fortification against General Grant's approach, and the topographical features of the country included within them.

Topography and hydrography at Cairo and Mound City, Illinois.—This survey was commenced by Mr. Fendall, in December, with a party in the small gunboat *Alexandra*. After the arrival of Assistant Gerdes, in January, a triangulation was laid out to include the entire course of the Ohio river from Mound City to Cairo, and points were occupied on the Kentucky shore; but several surveys being ordered soon after, the work was suspended until the 29th of May. Mr. Fendall had then returned from the Red river, and Mr. Gerdes had completed work on the Mississippi. With the entire force of his party the survey of the Ohio was pushed to completion before the end of June. The small steamer *Tensas* was used in making the soundings. The map was constructed without delay, and a copy of it was furnished to Admiral Porter. It embraces (see sketch No. 31) all the topographical details of about seven miles of both shores of the Ohio and the river hydrography. Assistant Gerdes made also, at the request of the admiral, a special survey of the naval depot, and subsequently a chart of the harbor and river front at Mound City, and presented the results in the form of maps on a large scale.

Topographical surveys on Red river, Louisiana.—Quarters being provided for him on the flag-ship *Black Hawk*, of the Mississippi squadron, Sub-Assistant Fendall went on board on the 20th of February, and accompanied the expedition up the Red river. By direction of Admiral Porter he made a survey of Semmesport, on the Atchafalaya, and subsequently of the vicinity of Fort DeRussy. By the 4th of April he had finished an extensive topographical survey of the country around Alexandria, La., including the course of the Red river from the town as far up as the falls. Later he compiled for the use of the squadron sketches of the route from Alexandria to Grand Ecore, taking the requisite observations from a light-draught steamer. The vessel was several times attacked by the enemy, and received numerous shots in her hull and upper works.

Mr. Fendall was again at the mouth of Red river on the 1st of May, and returned with the flag-ship to Mound City. He reported at the office on the 29th of June.

Copies of all the surveys made by the party, working either jointly or separately, were furnished to Admiral Porter. The personal risk incurred in prosecuting the work was considerable. While returning from Grand Gulf the vessel of Assistant Gerdes had to engage a rebel battery of twelve guns at a point near Gaines's Landing, on the Arkansas shore of the Mississippi. The vessel was struck nine times by solid shot or shell, and several rifle balls passed through her cabin.

On taking leave of the squadron Assistant Gerdes and Sub-Assistant Fendall received written testimonials from the flag-officer expressing his satisfaction, and urging the return of the party in the fall for completing the reconnaissance of the Mississippi, on the plan adopted by Mr. Gerdes, between Rodney and Vicksburg. The utility of this service, so long as guard vessels are needed on that river, is obvious. It will be resumed by the party when preparations now under way are completed.

Surveys in Louisiana and Texas.—At the date of my last annual report Assistant J. G. Oltmanns was attached to the staff of Major General Franklin, and was proceeding with the 19th army corps in the Red river campaign. Before leaving New Iberia he made a military map of its approaches to show also the positions of the different corps, divisions, picket lines, &c. A survey of the same character was made at Franklin in the latter part of December, and in the following month reconnaissances to Côte Blanche bay over a district with which the previous operations of Mr. Oltmanns on Coast Survey duty had made him familiar. He accompanied the army to Alexandria in March, and, with an escort, advanced beyond that post and found the picket lines of the enemy. At Natchitoches, where the army halted, he made a preliminary survey of the approaches, and of the ground occupied. Mr. Oltmanns served as aide-de-camp in the encounter with the enemy at Sabine Cross Roads, in which the bridle was cut away from his hand by a shell; and in

the battle at Pleasant Hill, which checked the rebel advance. He made a survey of the intrenched ground at Grand Ecore, at the junction of Red river and Old river, and connected it with the survey of Natchitoches. On the return of the army to Alexandria he was actively engaged in staff duty, and in making quick reconnaissances for verbal report. He accompanied the staff of Major General Franklin to New York in July, the wound received by that officer at Sabine Crossroads having compelled him to leave the department. Assistant Oltmanns was in continuous service with the army in Louisiana during twenty-one months. He returned to the office in August last, and in September joined the army in the Shenandoah valley, in Virginia.

Sub-Assistant Charles Hosmer reported to Major General Banks at New Orleans on the 22d of October, 1863. He was present for duty at Brazos Santiago in November, but was recalled to attend the army detachment at Aransas Pass, where he determined the changes which had occurred on that bar, and located and marked on a map the position of the rebel defences. At Pass Cavallo the same kind of service was rendered. He traced also the changes in shore-line at the eastern end of Matagorda island, mapped the Pelican islands, and buoyed out the channel into McHenry bayou. At the request of Brigadier General Grover Mr. Hosmer joined his staff at Franklin, La., early in January, after recovering from illness contracted in duty on the coast of Texas. In the course of the next two months a survey was made of the vicinity and defences of Madisonville, in the erection of which Mr. Hosmer assisted. As in all similar cases, the map of this survey was sent to the chief engineer, Major D. C. Houston. Mr. Hosmer then rejoined the staff, attended General Grover on a visit to Thibodeaux, and accompanied him to Alexandria in the movement which was made up the Red river. On the return of the army, a topographical sketch of the vicinity of Morganza was made for Brigadier General Emory. Similar duty was performed at Fort Adams, Miss., Mr. Hosmer having accompanied the army division to that post in June. Returning to Morganza in the latter part of the month, he proceeded to New Orleans with General Grover, and, on his arrival, was relieved from service in the department of the Gulf.

Sub-Assistant Hosmer, after reporting at the office, joined the party of Assistant Harrison, as stated under the head of Section I. He has furnished to the office copies of all the surveys which he made for military use in Louisiana and Texas.

SECTION X.

FROM SAN DIEGO OR THE SOUTHERN BOUNDARY ON THE PACIFIC TO THE FORTY-SECOND PARALLEL, INCLUDING THE COAST OF CALIFORNIA.

The work on the western coast will be described in the reverse geographical order, or from south to north, contrary to the order observed in the preceding part of this report. Appendix No 1 shows the arrangement of the parties, the persons employed, and their sites of work. The different surveys will here be referred to in detail.

Coast triangulation north of Monterey bay, California.—The party of Assistant W. E. Greenwell took the field on the 1st of April at Monterey bay. After connecting the primary triangulation with Point Pinos and Santa Cruz stations, the coast triangulation was continued northward and westward to stations above Point Año Nuevo. The points used by the topographical parties in tracing the coast line in former years were included as far as practicable in this triangulation. Field-work was continued until the middle of October.

Sub-Assistant Julius Kincheloe was attached to the party, and effectively co-operated in its duties.

The following is a summary of the statistics :

Signals erected.....	28
Stations occupied.....	26
Objects observed on.....	31
Number of observations.....	3, 668

The angles were measured with the theodolite No. 44.

Triangulation westward of Santa Barbara, California.—The party of Assistant Greenwell were still in the field when my last annual report was closed. About eight miles of the coast triangulation, westward of Santa Barbara, was added to the work previously reported, before the return of the schooner Humboldt to San Francisco.

The following are the statistics :

Signals erected.....	10
Stations occupied.....	10
Angles measured.....	31
Number of observations.....	908

Sub-Assistant Kincheloe assisted in this work. Ten volumes, containing the original records of the triangulation about Santa Barbara, have been received from Assistant Greenwell during the present season.

Triangulation of Suisun bay, California.—The triangulation of Suisun bay was commenced on the 28th of July by Assistant J. S. Lawson, with a party, in the brig Fauntleroy.

Almost the entire shore-line of the bay is bordered by marsh, off which are extensive flats of very soft mud. By taking advantage of high water the reconnaissance was successfully made, and points were determined for the use of the hydrographic party. Mr. Lawson erected ten signals, and by the 1st of September had occupied two stations with the theodolite, and measured twenty-two angles by nine hundred and fifty-two observations. The triangulation is yet in progress. A stretch of about nine miles will be included in the triangulation work of the present season.

Mr. C. B. Boutelle aided in the party of Assistant Lawson until the 1st of May, and was then transferred to the hydrographic party of Assistant Edwards.

Hydrography of Half Moon bay, California.—This work was commenced by the party of Assistant A. F. Rodgers on the 11th of September, 1863, and was completed on the 23d of the following month.

To the southward of the ordinary course to the anchorage under Point Miramontes Mr. Rodgers developed a dangerous ledge of rocks extending about half a mile in a direction parallel to the coast, and nearly two miles off shore. The reef has an average depth of three and a half fathoms, but is much broken, and is marked at its southern end by a rock with only four feet of water.

Of Half Moon bay as a harbor Assistant Rodgers reports as follows: "The anchorage is not much to be recommended except as an alternative, although the approaches to it are plain, and the water between the reef and the beach bold, and shoaling gradually on either hand, so as to make it easy by the use of the lead to reach the anchorage without risk. There is no shelter except from northwest winds, and with these a heavy sea rolls over the reef and reaches the anchorage." * * * "The holding ground is bad, being apparently of sandstone formation without deposit, or, if any, so slight as to be useless in holding an anchor."

For determining the positions of signals to be used in the hydrographic work Mr. Rodgers made a supplementary triangulation. His party erected nine signals. From the stations marked by them thirty-four angles were measured by six hundred and ninety observations. The statistics of the hydrography which is comprised on three sheets are thus reported:

Miles run in sounding	428
Angles measured	2,000
Number of observations	15,327
Area sounded, (square miles)	54 $\frac{3}{4}$

Assistant Rodgers highly commends the services rendered by his aid, Mr. Alex. Chase.

The original sheets of the hydrographic survey of Half Moon bay were inked in the course of the season, and are now on file in the office. Assistant Rodgers remarks in closing his report: "Half Moon bay is the shipping point for a large and fertile farming country, some five thousand tons of produce being freighted thence to San Francisco every season. An unbroken view of fields of wheat, oats, barley, and potatoes, which are the staples, and which grow with luxuriance, attests the fertility of the soil. It is cultivated to the very edge of the bluffs which overhang the coast for a distance of twenty-five miles north and south of the anchorage."

Resurvey near Mare island navy yard.—At the request of the commandant the channel of Mare Island strait, opposite to the navy yard, was resurveyed in March by Assistant Rodgers, with a view to determine the extent of changes that might have occurred, and to facilitate the operations necessary in dredging. In making the requisite soundings two hundred and forty-nine positions were determined, and nearly five thousand casts were made with the lead. The hydrography included the entire breadth of the strait from the northwest end of the island down to the junction of Mare island and Karquines straits.

Assistant Lawson, being then in the vicinity of Mare island, co-operated in this survey, as did also Assistant Edwards, who arrived in the section before the soundings were completed.

Assistant Rodgers was called upon in November to make a hydrographic survey around the ship *Aquila*, that vessel having sunk at San Francisco with a valuable freight. This was promptly done, and the results, showing the best mode of proceeding in order to save the plates of the monitor *Camauche*, were furnished to the naval authorities.

Hydrography.—On the 1st of March Assistant W. S. Edwards was assigned to duty on the western coast, with instructions to take charge of the schooner *Marcy*, and to succeed Assistant Rodgers in the direction of the hydrographic work. He proceeded at once to San Francisco, and prosecuted some supplementary

duty in Mare Island strait, in order to furnish reliable data for dredging operations contemplated at and near the wharves of the navy yard. Tracings from the sheet of soundings were furnished in June to Commander Selfridge, United States navy, commandant of the yard.

Early in August Mr. Edwards set up signals, and commenced the hydrography of Suisun bay, following the preliminary survey which was begun at the same time by Assistant Lawson. Soundings were continued during a fortnight, but were suspended to meet the request of Commandant Selfridge for information concerning the mud flat between San Pablo Point and Pinole Point, in San Pablo bay, where the United States storeship Farallones was ashore. The flat was examined by Assistant Edwards, and a comparative chart showing his soundings and those made by Commander Alden in 1854 was furnished to the commandant.

On the 4th of September the party in the Marcy took up the off-shore hydrography between Point Piedra and Point Año Nuevo, and at the date of the last report by Assistant Edwards was still engaged in its prosecution.

The hydrography of Suisun bay will be resumed and completed if practicable during the winter.

Mr. C. B. Boutelle joined the party as aid on the 1st of May.

New editions of the reconnaissance charts of the western coast are given with this report, (Sketches Nos. 32, 33, and 34,) and a general chart of the coast between Point Pinos and Bodega Head, as Sketch No. 35.

Tidal observations.—The self-registering tide-gauges at San Diego and San Francisco were kept at work successfully by Messrs. A. Cassidy and H. E. Uhrlandt, under the general supervision of Captain G. H. Elliot, of the corps of engineers.

Mr. Uhrlandt has also read off, as heretofore, all the records of the self-registering tide-gauges of the western coast.

SECTION XI.

FROM THE FORTY-SECOND PARALLEL TO THE NORTHWESTERN BOUNDARY OF THE UNITED STATES, INCLUDING THE COAST OF THE STATE OF OREGON AND THE COAST OF WASHINGTON TERRITORY.

The party usually assigned to duty in this section having completed the survey to be noticed under the following head, took up service in Section X. Its labors there have been referred to in the preceding chapter.

Triangulation and shore line survey of Koos bay, Oregon.—The survey of Koos bay was in progress when my report of last year was closed. In addition to the work then reported, Assistant J. S. Lawson occupied seven stations, and measured ninety-three angles by two thousand five hundred and twenty-six observations with the ten-inch Gambey theodolite No. 20. A preliminary topographical survey made at the same time comprises forty-one miles of shore-line, and nineteen miles of outline of marsh.

The following is an extract from the concluding report of Assistant Lawson:

"From North Bend to the head of Koos bay there are but two narrow channels. The main one and the only one available for vessels of any draught is quite close to the western shore, and leads into the slough on which the coal mines are situated. The other lies on the eastern side and is narrow. In some places it approaches near to the shore, and in others winds through the flats, which are bare at low water, and embrace nearly all of this part of the bay. This channel is used only by boats. It leads directly into Koos river, which empties into the southeast end of the bay. Across the head of the bay there is a third channel connecting the two just described, but it is of no importance. Near the mouth of the river there are several snags that narrow the channel, and give it an irregular course."

"Along the line of low water in each of these channels small signals were placed from one hundred to three hundred metres apart. These, in running the shore-line of the bay, were determined in position by the plane table. The same was done in other parts of the bay where the flats extended any considerable distance from the shore, as off Pony Point."

Assistant Lawson completed at San Francisco the office work connected with the triangulation of Koos bay, and forwarded the sheet containing the shore-line survey. His subsequent work has already been referred to.

Tidal observations.—The station at Astoria, Oregon, has remained in charge of Mr. L. Wilson, under the general supervision of Captain G. H. Elliot, United States engineers. The very complete meteorological record kept by Mr. Wilson deserves special mention.

COAST SURVEY OFFICE.

The office in Washington has remained under the supervision of *J. E. Hilgard, esq.*, the assistant in charge. *Professor F. A. P. Barnard* acted as general assistant until the 1st of June, and then accepted the presidency of Columbia College. Full details are given in the report of the assistant in charge (Appendix No. 10) in regard to occupation in each division of the office. A short abstract of that report is here appended.

Hydrographic division.—The duties of this section of the work, including the care and outfit of vessels for the use of field parties, have been directed, as heretofore, by *Captain C. P. Patterson*. The general occupation consists of the verification of original hydrographic sheets, the preparation of sailing directions, the revision of published charts when new material is received, and the ordinary routine required for keeping hydrographic publications up with the latest information.

Two draughtsmen, *Messrs. Arthur Balbach* and *Louis Karcher*, have been attached to this division, the last named until the end of September, when he retired from the office.

Tidal division.—In this branch of the office tidal notes are adjusted for each of the hydrographic charts as they pass into the engraving division. *Assistant L. F. Pourtales*, in charge of the tidal division, attends also to the arrangements needful for keeping up observations at the permanent tidal stations on the coast. A report on the records received during the year is given in Appendix No. 10.

Mr. P. H. Donegan was on duty in the division until the 1st of April, when he was replaced by *Mr. John Downes*. The ordinary reductions and copying from the tidal registers have been done by *M. Thomas* and *F. R. Pendleton*.

Computing division.—The report of *Assistant Charles A. Schott*, who retains the charge of this division, (Appendix No. 10,) states the occupation of each of the computers. *Mr. James Main* resigned his place in the division on the 1st of August. *Mr. R. S. Avery*, formerly attached to the tidal division, has served as computer during the year, as have also *Assistant T. W. Werner*, *Mr. E. Nulty*, and *Dr. Gottlieb Rumpf*. The clerical duties of the division have been performed by *Mr. E. Courtenay*, and *R. Freeman* has made transcripts of miscellaneous computations.

The report of *Mr. Scott* gives details in regard to several interesting subjects referred to him in the course of the year, and which were exclusive of the direction of work in the computing division.

Drawing division.—Under the direction of *Assistant J. E. Hilgard* the distribution of work in this branch of the office has been made by *Mr. W. T. Bright*. Of the draughtsmen employed, *Assistant M. J. McClary*, *Mr. E. Hergesheimer*, and *J. W. Maedel*, (the last named until December, 1863,) were engaged in preparing photographed reductions for the map engravers, *Mr. L. D. Williams* in miscellaneous work until the end of November, 1863, when he resigned. *Mr. A. Lindenkohl* has been chiefly employed in the compilation of military maps, and *Mr. H. Lindenkohl* in making projections when not engaged for the lithographic division. *Mr. F. Fairfax* has been employed in ordinary reductions from plane-table sheets, and *Messrs. E. Willenbacher* and *W. B. McMurtrie* principally in plotting hydrographic work. *Messrs. B. Hoov*, *W. Fairfax*, *J. H. Logan*, and *D. Koch* have made the tracings called for during the year, the last named until October, when he was replaced by *Mr. H. Custer*.

The details of work done by each of the draughtsmen are stated in the Appendix No. 10.

Engraving division.—The force in the engraving division has been directed, as heretofore, by *Mr. Edward Wharton*. The topographical engraving has been executed by *Messrs. A. Rolle*, *J. Enthoffer*, *A. Sengteller*, *W. Phillips*, *H. C. Evans*, *H. S. Barnard*, *A. M. Maedel*, *R. F. Bartle*, and *W. A. Thompson*; *Messrs. J. Knight*, *E. A. Madel*, and *W. H. Davis* have been employed in lettering, and *Messrs. J. C. Kondrup*, *A. Petersen*, *F. W. Benner*, *E. H. Sipe*, and *J. G. Thompson* in miscellaneous engravings. The use of punches for soundings in lieu of cut figures has been continued by *Mr. A. Buckle*. The clerical service required in the division was performed at successive periods of the year by *Mr. G. J. Pinckard*, *Mr. H. C. Saxton*, and *Mr. George C. Scharffer, jr.* Appendix No. 10 contains a synopsis of the work done by each engraver.

Photograph and electrotype division.—A summary of the work done in this part of the office is given in the report of *Mr. George Mathiot*. (Appendix No. 10.) In several instances during the year the facility afforded by the photographic process has availed for the speedy issue of maps, which could not have been otherwise produced in the time allotted for their issue.

Lithographing division.—Until June the operations in this section of the office were directed by *Professor F. A. P. Barnard*, who also had charge of the map printing. The work in both branches has since been under the supervision of *Mr. W. W. Cooper*, whose report will be found appended to that of the assistant in charge of the office, in Appendix No. 10.

Mr. C. G. Krebs has been employed during the year as lithographic engraver, and *Messrs. Archibald, Brown* and *James Ruhl* as printers. The drawings required in the division were made by *Mr. A. Lindenkohl*, assisted by *Mr. H. Lindenkohl*. *Mr. E. Molitor*, temporarily attached to the drawing division, aided also in lithographing.

Map printing.—An aggregate of sixty-five thousand eight hundred and ninety-seven copies of maps and charts have been printed during the year. Of this number two-thirds were hydrographic charts, printed in part from the copper plates, and partly by the transfer process. The copper-plate press has been worked as heretofore by *Mr. John Rutherford*. More than twenty-two thousand copies of military maps and sketches were printed in the course of the present year. The series of lithographic maps now comprise nearly the entire area of the rebellious States that lie east of the Mississippi. The lithographic presses on which the maps are printed have been worked by *Messrs. Brown* and *Ruhl*.

Distribution of maps and annual reports.—Of the maps and charts printed during the year, fifty-three thousand seven hundred copies have been distributed to the navy, to captains and pilots employed in the transport service, to military officers, sale agents, and civilians. Of that aggregate thirty-six thousand six hundred and ninety-seven copies were hydrographic charts. A summary of the distribution by *Mr. M. T. Johnstone*, who remains in charge of the map-room, is given in the Appendix No. 10, together with a statement in reference to the distribution of copies of the annual reports.

Of the number of sheets of military maps printed during the year, seventeen thousand copies were issued from the office. The record of this distribution is kept by *Mr. V. E. King*.

To *Samuel Hein, esq.*, the disbursing officer of the Coast Survey, and to *Captain C. P. Patterson*, hydrographic inspector, my special acknowledgments are due for constant interest in the work, and for their effective co-operation.

My principal clerk, *W. W. Cooper, esq.*, has acceptably performed his usual office duties in addition to those already mentioned, and *Mr. J. T. Hoover* the clerical service with the superintendent in the field.

Respectfully submitted by

A. D. BACHE,
Superintendent United States Coast Survey.

Hon. WILLIAM P. FESSENDEN,
Secretary of the Treasury

APPENDIX.

APPENDIX No. 1

Distribution of the parties of the Coast Survey upon the coasts of the United States during the surveying season of 1863-'64.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION I. From Passamaquoddy bay to Point Judith, including the coast of Maine, New Hampshire, Massachusetts, and Rhode Island.	No. 1	Triangulation	G. A. Fairfield, assistant; H. Anderson, aid.	Triangulation of Union River bay completed, and connected with that of Great Blue Hill bay. (See also Section IV.)
	2	Triangulation	S. C. McCorkle, assistant....	Triangulation of Penobscot river extended from North Bucksport upwards, to Bangor.
	3	Topography	W. H. Dennis, sub-assistant; S. P. Holt, aid.	Preliminary survey of the eastern and north shore of Deer island (Passamaquoddy bay) and of the ledges between it and White Horse island. (See also Sections V and VI.)
	4	Topography	F. W. Dorr, sub-assistant; Frank Granger, aid.	Shore-line survey of Manhegan and other islands at the southwestern entrance of Penobscot bay. (See also Sec. VIII.)
	5	Topography	Charles Ferguson, sub-assistant.	Plane-table survey from the Narrows southward, completing the topography of St. George's river, Me. (See also Section III.)
	6	Topography	P. C. F. West, assistant....	Topographical survey of the eastern side of the Sheepscot river, Me., from Ebenecook harbor southward to Cape Newagen, and eastward to include Booth bay harbor and the coast between Spruce Point and Squirrel island. (See also Sections III and VIII.)
	7	Topography	R. E. McMath.....	Detailed plane-table survey of the eastern side of the Sheepscot river, Me., completed below Wiscasset and survey of part of Westport island. (See also Sections III and VI.)
	8	Topography	I. Hull Adams, assistant....	Topography nearly completed on the shores of water passages between the Sheepscot and Kennebec rivers, Me.
	9	Topography	R. M. Bache, assistant.....	Detailed survey continued on the south shore of the Androscoggin between the Kennebec river and Brunswick, Me.
	10	Topography	A. W. Longfellow, assistant..	Interior details filled in, completing the plane-table survey of Great Jedge, Cousin's, Littlejohn's, and other islands, and the Cumberland shore of Casco bay; shore-line of the Gurnet traced, between Orr's and Great island.
	11	Topography	A. M. Harrison, assistant; Chas. Hosmer, sub-assistant.	Detailed plane-table survey including the shores of Warren, Barrington, and Kickemuit river and Bristol neck, with the shores of Bristol harbor and Mt. Hope bay. (See also Sections VIII and IX.)

REPORT OF THE SUPERINTENDENT OF

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION I— Continued.	No. 12	Hydrography.....	F. P. Webber, sub-assistant; C. P. Dillaway, Franklin Platt, jr., Cleveland Abbe, and M. M. Defrees, aids.	St. George's river, Me., sounded, from Thomaston southward to the entrance, and junction made with inshore hydrography of the coast of Maine. (See also Section V.)
	13	Hydrography.....	Alexander Strausz, acting assistant; C. S. Hein, L. A. Sengteller, aids.	Soundings in Quobog bay, Me., completed from Lovell's cove southward to Bailey's island and eastward to Small Point peninsula. (See also Section IV.)
	14	Hydrography.....	Lieut. Comdr. T. S. Phelps, U. S. N., assistant.	Extension of the hydrography southward and eastward from Portland entrance, and development of White Head ground, off Cape Elizabeth. (See also Sections II and IV.)
	15	Physical survey ...	Henry Mitchell, assistant....	Compilation of data derived from the special survey of Boston harbor, for the United States commissioners. Hydrographic examination in New Bedford harbor, Mass.; and for aids to navigation in Penobscot and Passamaquoddy bays.
	16	Magnetic and tidal observations.	Edward Goodfellow, assistant, (part of season;) A. T. Mosman, sub-assist't, (part of season.)	Tidal and magnetic observations continued at Eastport, Me., until August. (See also Sections II and III.)
	17	Magnetic and tidal observations.	H. W. Richardson.....	Observations at Portland with tide-gauge and magnetic instruments transferred from Eastport.
	18	Tidal observations...	T. E. Ready.....	Self-registering observations continued at the Charlestown navy yard, Mass.
SECTION II. From Point Judith to Cape Henlopen, including the coast of Connecticut, New York, New Jersey, Pennsylvania, and part of Delaware.	1	Geodetic and magnetic observations.	A. D. Bache, superintendent; G. W. Dean, assistant; R. E. Halter, sub-assistant; F. W. Perkins, J. J. Gilbert, aids.	Wooster Mountain, near Danbury, Conn., occupied, and additional observations made at Bald Hill, Conn., for connecting the Epping base in Section I with the base on Fire island. Magnetic declination, dip and intensity determined at Wooster Mountain. (See also Sections III and IV.)
	2	Triangulation	Edmund Blunt, assistant; J. A. Sullivan, sub-assistant; A. T. Mosman, sub-assistant, (part of season.)	Triangulation connecting the primary work in this Section with the triangulation of Hudson river.
	3	Triangulation	John Farley, assistant.....	Triangulation of the coast of New Jersey extended from Manasquan inlet southward to Tom's river, including the shores of Barnegat bay.
	4	Topography.....	H. L. Whiting, assistant; C. Rockwell, sub-assistant, (part of season;) H. G. Ogden, aid.	Detailed topography of Hudson river extended from Nyack and Sing Sing northward to Haverstraw and Croton village. (See also Sections III and VIII.)
	5	Topography.....	C. M. Bache, assistant; T. C. Bowie, sub-assistant.	Supplementary plane-table survey of the highlands of Navesink, N. J. (See also Sections III and VIII.)
	6	Topography.....	H. W. Bache, in charge; H. G. Ogden, aid.	Plane-table survey of Absecon inlet, N. J., including Atlantic City and Brigantine beach. (See also Sections III and IV.)
	7	Hydrography.....	Lieut. Comdr. T. S. Phelps, U. S. N., assistant.	Hydrography of Absecon inlet, the approaches and harbor. (See also Sections I and IV.)

APPENDIX No. 1—Continued

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION II— Continued.	No. 8	Special examination.	Henry Mitchell, assistant; J. W. Brown, A. M. Wetherill, aids.	The effect of floating ice observed in Delaware river at sites proposed for a navy yard. (See also Section I.)
	9	Tidal observations.	R. T. Bassett.	Observations continued with the self-registering gauge at Governor's island (New York harbor) and with a box-gauge at Brooklyn.
SECTION III. From Cape Henlopen to Cape Henry, including the coast of part of Delaware; the coast of Maryland, and part of the coast of Virginia.	1	Astronomical observations.	G. W. Dean, assistant; A. T. Mosman, sub-assistant; S. H. Lyman, aid.	Longitude determined by telegraphic exchanges between Washington, D. C., and Martinsburg, Clarksburg, Cumberland, Grafton, Cameron, Wheeling, Parkersburg, Point Pleasant, and Gauley bridge, W. Va., and with South Point, Ohio. Observations for latitude and for the magnetic elements at the same stations, and at Charleston, W. Va. (See also Section I.)
	2	Topography.	C. T. Iardella, sub-assistant; C. M. Bache, assistant, (part of season;) H. W. Bache, aid.	Plane-table survey of ground occupied for defensive purposes in the environs of Baltimore, Md. (See also Section II.)
	3	Topography.	Charles Ferguson, sub-assistant.	Supplementary plane-table survey completed outside of the northeast boundary of the District of Columbia, below Bladensburg, Md. (See also Section I.)
	4	Topography.	E. Hergesheimer, R. E. McMath.	Minute topographical survey of Arlington Heights, Va., and contour of the ground mapped by levelling, for the War Department. (See also Sections I and VI.)
	5	Reconnaissance.	P. C. F. West, assistant.	Reconnaissances west and north of Bermuda Hundred, in connexion with military duty in the army of the James river, Va. (See also Sections I and VIII.)
	6	Topography.	J. W. Donn, sub-assistant; H. L. Marindin, aid.	Plane-table surveys for military purposes at Bermuda Hundred, Va. (See also Section VIII.)
	7	Topography.	C. Rockwell, sub-assistant.	Special topographical survey near Sewall's Point for military purposes. (See also Section VIII.)
	8	Topography.	J. G. Oltmanns, assistant.	Military service and reconnaissance duty with the 19th army corps in the Shenandoah valley, Va. (See also Sec. VIII.)
	9	Topography.	A. Lindenkohl.	Special service at Clarksburg, W. Va., in connexion with the military map of West Virginia.
	10	Hydrography.	J. S. Bradford, sub-assistant.	Trent's Reach (James river, Va.) sounded and charts made for the use of the North Atlantic blockading squadron. (See also Section IV.)
	11	Tidal observations.	M. C. King, (part of season;) C. Kelly.	Series of observations continued at Old Point Comfort with the self-registering tide-gauge.
SECTION IV. From Cape Henry to Cape Fear, including part of the coast of Virginia and part of North Carolina.	1	Triangulation and topography.	R. E. Halter, sub-assistant.	Triangulation and topography of Roanoke river, N. C., from Ryan's Thoroughfare to the mouth. Triangulation and shoreline survey of Croatan sound, N. C. Topography of Roanoke island completed. (See also Section II.)
	2	Triangulation.	G. A. Fairfield, assistant; H. Anderson, aid.	Triangulation of the Neuse river, N. C., continued in the vicinity of Goose creek. (See also Section I.)

REPORT OF THE SUPERINTENDENT OF

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION IV— Continued.	No. 3	Hydrography.....	J. S. Bradford, sub-assistant; H. M. DeWees and H. L. Marindin, aids.	Roanoke river, N. C., sounded from its mouth upward to Ryan's Thoroughfare, including also Bachelor's bay and Middle and Eastmost rivers. Hydrographic survey of Croatan sound and development of the artificial obstructions. Buoys were set in the channel from Roanoke marshes to Croatan light. Reconnaissance of Bogue sound, N. C. (See also Section III.)
	4	Hydrography.....	Alexander Strausz, acting assistant; H. G. Ogden and Gershoni Bradford, aids.	Hydrographic resurvey of Hatteras inlet and Beaufort harbor, N. C. Hydrography of the Neuse river commenced in the vicinity of New Bern, and buoys set to mark the channel. (See also Section I.)
	5	Hydrography.....	Edw. Cordell, acting assistant; A. M. Wetherill, J. W. Brown, and Franklin Platt, aids.	Hydrography of Core sound, N. C., completed, and channel marked by buoys from Bogue sound through the Strait. Resurveys of the entrance to Beaufort harbor, N. C., and of Hatteras inlet. General duty in the Section for the Light-house Board.
	6	Hydrography.....	Lieut. Comdr. T. S. Phelps, U. S. N., assistant.	Development by reconnaissance soundings of the Cape Lookout shoals. (See also Sections I and II.)
SECTION V. From Cape Fear to St. Mary's river, Ga., including the coast of part of North Carolina, and the coast of South Carolina and Georgia.	1	Hydrography.....	W. S. Edwards, assistant; F. H. Dietz, A. R. Fauntleroy, and L. A. Sengteller, aids, (part of season.)	Resurvey of the bar and channels leading into Charleston harbor, S. C., and determination of the position of buoys and obstructions in the inner harbor. (See also Section X.)
	2	Topography and hydrography.	C. O. Boutelle, assistant; F. P. Webber, sub-assistant; W. W. Harding, L. L. Nicholson, C. P. Dillaway, and J. A. Guldin, aids.	Development of the new channels into Charleston entrance. Shore-line survey of Morris and Folly islands, S. C., and sounding of Light-house inlet and Folly river. Reconnaissance and pilot duty through the inland passage from Beaufort into St. Helena sound and in South Edisto river for vessels of the South Atlantic blockading squadron. Hydrography of the approaches to Wasaw sound, Ga. (See also Section VI.)
	3	Topography.....	W. H. Dennis, sub-assistant; S. P. Holt, aid.	Plane-table survey of Bay Point and of Lands' End (Port Royal, S. C.) and shore-line survey of Morris and Folly islands. (See also Sections I and VI.)
SECTION VI. From St. Mary's river, Ga., to St. Joseph's bay, Fla., including the eastern and part of the western coast of Florida peninsula, and the Florida reefs and keys.	1	Topography.....	W. H. Dennis, sub-assistant; S. P. Holt, aid.	Survey of the vicinity of Jacksonville and Palatka, Fla., for military purposes. Reconnaissance of roads leading from Jacksonville to St. Augustine, to Pico-lata, and to Mayport Mills, and shore-line survey of the mouth of St. John's river. (See also Sections I and V.)
	2	Topography.....	R. E. McMath.....	Special service at Fernandina and St. Augustine and compilation of maps for the use of the direct tax commissioners of Florida. (See also Sections I and III.)
	3	Hydrography.....	C. O. Boutelle, assistant; Robert Platt, acting master, U. S. N., W. W. Harding, A. R. Fauntleroy, L. L. Nicholson, and C. P. Dillaway, aids.	Hydrographic resurvey of the bar of St. John's river, Fla., and of the channel upward to Mayport Mills. Buoys set and pilot duty rendered for vessels of the South Atlantic blockading squadron. (See also Section V.)
	4	Magnetic observations.	Samuel Walker.....	Observations continued at the Key West station.

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTIONS VII, VIII AND IX. From St. Joseph's bay, Fla., westward to the Rio Grande, including part of the western coast of Florida, and the coast of Alabama, Mississippi, Louisiana, and Texas.	No. 1	Topography.....	Cleveland Rockwell, sub-assistant; R. H. Talcott, aid.	Topographical survey of the vicinity of Knoxville, Tenn., for military purposes.
	2	Topography.....	Cleveland Rockwell, sub-assistant.	Plane-table survey of Strawberry Plains, Tenn., for military purposes.
	3	Topography.....	F. W. Dorr, sub-assistant; J. W. Donn, sub-assistant.	Topographical survey of the vicinity of Nashville, Tenn., for military purposes. (See also Sections I and III.)
	4	Reconnaissance....	P. C. F. West, assistant.....	Military service and reconnaissances in connexion with the army of the Cumberland preceding and at the battle of Lookout mountain. (See also Sections I and III.)
	5	Topography.....	F. W. Dorr, sub-assistant; J. W. Donn, sub-assistant.	Plane-table survey of ground commanded by the defences of Chattanooga, Tenn., including Lookout mountain and valley, Raccoon mountain and Moccasin Point. (See also Sections I and III.)
	6	Reconnaissance....	Clarence Fendall, sub-assistant.	Reconnaissance for a road for military purposes across Raccoon mountain from Kelly's ferry to Whiteside, Tenn.
	7	Triangulation and topography.	C. H. Boyd, sub-assistant...	Triangulation and plane-table survey of the battle-ground at Chickamauga, Ga., and its connexion with surveys in the vicinity of Chattanooga, Tenn.
	8	Triangulation, topography, and hydrography.	F. H. Gerdes, assistant; C. Fendall and T. C. Bowie, sub-assistants; J. B. Adamson, aid.	Shore-line survey and hydrographic reconnaissance of the Mississippi river between Rodney and Palmyra bend. Complete survey including the river at Grand Gulf, Miss. Completion of the plane-table survey of the defences of Vicksburg. Topography and hydrography of the Ohio river between Cairo and Mound City, Ill., and topographical surveys of Semmsport, Fort DeRussy and of the banks of Red river, La., between Alexandria and the falls.
	9	Reconnaissance and topography.	J. G. Oltmanns, assistant....	Military services reconnaissance and topographical surveys in connexion with the 19th army corps in Louisiana. (See also Section III.)
	10	Topography.....	Charles Hosmer, sub-assistant.	Topographical duty for the army of the Gulf at Aransas Pass, Pass Cavallo, and Matagorda entrances, Texas, at Madisonville and Morganza, La., and at Fort Adams, Miss. (See also Section I.)
SECTION X. From San Diego or the southern boundary of the United States on the Pacific to the forty-second parallel, including the coast of California.	1	Triangulation.....	W. E. Greenwell, assistant; Julius Kincheloe, sub-assistant.	Triangulation of the shore of Santa Barbara channel, Cal., extended from former limits towards Point Conception. Coast triangulation continued from Monterey bay northward and westward to Point Año Nuevo.
	2	Triangulation.....	J. S. Lawson, assistant; C. B. Boutelle, aid, (part of season.)	Triangulation of Suisun bay, Cal., commenced and extended from eastward. (See also Section XI.)
	3	Hydrography.....	Aug. F. Rodgers, assistant; Alexander Chase, aid.	In-shore hydrography completed between Point San Pedro and Tunitas creek, including Half Moon bay, Cal. Hydrographic resurvey of Mare Island strait.

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION X— Continued.	No. 4	Hydrography.....	W. S. Edwards, assistant; C. B. Boutelle, aid, (part of season.)	Resurvey of Mare Island strait and examination of San Pablo bay, between San Pablo Point and Pinole Point; soundings in Suisun bay and inshore hydrography between Point Piedra and Point Año Nueva. (See also Section V.)
	5	Tidal observations.	Captain G. H. Elliot, U. S. engineers, in charge; A. Cassidy and H. E. Uhrlandt.	Observations continued with self-registering gauges at the tidal stations near San Diego and San Francisco.
SECTION XI. From the 42d parallel of latitude to the northwestern boundary of the United States, including the coast of the State of Oregon and the coast of Washington Territory.	1	Triangulation and shore line survey.	J. S. Lawson, assistant; C. B. Boutelle, aid.	Triangulation of Kees bay, Oregon, completed and shore-line traced. (See also Section X.)
	2	Tidal observations.	Louis Wilson	Series continued with the self-registering tide-gauge at Astoria, Oregon.

APPENDIX No. 2.

Information furnished from the Coast Survey office by tracings from original sheets, &c., in reply to special calls, during the year 1863-'64.

Date.	Names.	Data furnished.
1863.		
Nov. 2	C. H. Haswell, esq.....	Table of latitudes and longitudes of principal cities of the United States, determined by the United States Coast Survey.
9	E. P. Hannaford, esq.....	Table of prominent geographical positions in Maine.
13	Lt. Col. B. S. Alexander, corps of engineers...	Hydrographic and topographical survey of part of the Narrows, N. Y.
24	Major Gen. John J. Peck, U. S. A.....	Topographical survey of Smith's island, entrance to Cape Fear river, N. C.
25	U. S. tax commission for South Carolina.....	Connected topographical survey from St. Helena sound to the Savannah river, including Port Royal island.
Dec. 5	Prof. Powalky, Berlin, Prussia.....	Latitude and longitude of American stations occupied for observing the last transit of Venus in 1769.
16	Hon. L. M. Sweat, Maine.....	Topographical survey of Portland harbor, with colored proof of same.
22	Capt. T. L. Casey, corps of engineers.....	Table of magnetic declinations in Maine.
24	Rear-Admiral Lessofsky, Russian navy.....	Hydrographic survey of Smith's Island shoal, entrance to Chesapeake bay.
28	Major Charles E. Blunt, corps of engineers....	Topographical survey of Eastern Point, entrance to Gloucester harbor, Mass.
1864.		
January 4	War Department.....	Topographical survey of Pass Cavallo and Aransas pass, Texas, showing rebel fortifications and rifle pits.
4	Navy Department.....	Topographical survey of Pass Cavallo and Aransas pass, Texas, showing rebel fortifications and rifle pits.
4	Engineer department	Topographical survey of Pass Cavallo and Aransas pass, Texas, showing rebel fortifications and rifle pits.
7	Post Office Department.....	Topographical survey of part of Accomac county, with shoreline of sea-coast and eastern shore of Chesapeake bay.

APPENDIX No. 2—Continued.

Date.	Names.	Data furnished.
1864.		
January 23	Navy Department.....	Special survey for underwriters of ship Aquila, sunk at Hatha-way's wharf, San Francisco, with plates for monitor Can-manche aboard; also view of same.
February 4	Major Charles E. Blunt, corps of engineers....	Topographical survey of extremity of Cape Cod, Mass.
22	U. S. commission on Sandy Hook.....	Hydrographic resurvey of Sandy Hook, N. J.
March 8	Engineer department.....	Topographical survey western entrance to Narragansett bay, R. I.
9	Admiral S. P. Lee, U. S. N.....	Compiled map of Beaufort and vicinity, N. C.
16	Light-house Board.....	Topographical survey west side of the Thames river, vicinity of New London, Conn.
18	William Keeler, constructing engineer.....	Topographical survey west side of the Thames river, vicinity of New London, Conn.
18	Major Gen. A. E. Burnside, U. S. A.....	Compiled map State of North Carolina.
30	Hon. James K. Moorhead, Pa.....	Topographical survey of the Thames river, vicinity of New London, Conn.
April 15	Major Gen. W. F. Smith, U. S. A.....	Topographical survey of City Point, Va.
19	Hon. Samuel J. Randall, Pa.....	Topographical survey of League island and vicinity, Delaware river.
21	Major Gen. W. F. Smith, U. S. A.....	Topographical survey of the James river from City Point to Falling creek.
21	Col. R. Delafield, corps of engineers.....	Comparative map of Sandy Hook, from surveys of 1856 and 1863.
29	Major Gen. W. F. Smith, U. S. A.....	Complete topographical survey of the Appomattox river, Va.
29	.....do.....	Part of the topographical survey of the James river, Va., from Warwick bar to Richmond.
29	Admiral S. P. Lee, U. S. N.....	Hydrographic survey of Roanoke, Eastmost and Middle rivers, N. C.
29	.....do.....	Topographical survey of Roanoke, Eastmost and Middle rivers, N. C.
May 21	Lt. Comd. S. L. Phelps, U. S. N.....	Tracings of sketches of part of the Red river, La.
June 11	Northwest boundary commission.....	Topographical survey of Strawberry bay, W. T.
14	Gov. John A. Andrew, Mass.....	Topographical survey of Boston lower bay, Mass.
28	J. D. Jones, esq.....	Hydrographic and topographical survey of Cold Spring harbor, Long Island, N. Y.
July 2	Brig. Gen. C. Grover, U. S. A.....	Sketch of Red river and vicinity, from its mouth to Grand Ecote, La.
6	Brig. Gen. J. G. Barnard, chief engineer armies in the field.	Hydrographic survey of Appomattox river, Va.
6	Admiral S. P. Lee, U. S. N.....	Combined map of Croatan sound, N. C.
13	Brig. Gen. G. Weitzel, U. S. A.....	Topographical survey of Appomattox river, Va.
26	Engineer bureau.....	Topographical survey beyond the northeast and southeast boundaries of the District of Columbia.
27	Henry A. Webster, esq., Indian agent, Wash- ington Territory.	Sketch of Gray's harbor, W. T.
29	Admiral S. P. Lee, U. S. N.....	Hydrographic survey of Trent's reach, James river, Va.
August 1	A. Bowers, esq., California.....	Topographical survey of Petaluma creek, Cal.
3	Col. Henry Brewerton, U. S. A.....	Topographical survey west side of Baltimore, Md.
8	.....do.....	Topographical survey northwest side of Baltimore, Md.
10	Brig. Gen. A. P. Howe, U. S. A.....	Combined duplicate drawings of the Potomac river from Fort Washington to Alexandria.
12	Lt. Col. B. S. Alexander, corps of engineers....	Hydrographic survey off Fort Foote, Potomac river.
12	W. J. Newman, Light-house engineer.....	Topographical survey of Blakistone island, Potomac river.
12	Major J. C. Woodruff, corps of engineers.....	Topographical survey northeast of District of Columbia, from Bladensburg to Leesboro'.
16	Brig. Gen. J. A. Haskin, artillery defences of Washington.	Combined map of Potomac river from Fort Washington to Alexandria.

REPORT OF THE SUPERINTENDENT OF

APPENDIX No. 2—Continued.

Date.	Names.	Data furnished.
1864.		
August 16	Major Gen. J. G. Foster, U. S. A.....	Proof of coast map No. 53, scale $\frac{1}{80000}$, with details of topography colored.
16	Major Nathaniel Michler, corps of engineers...	Topographical survey of the Appomattox river, Va.
18	Hon. Charles O'Neill, Pennsylvania.....	Topographical survey mouth of the Housatonic river, Conn.
20	Engineer bureau.....	Topographical survey of Point Lookout, Md.
30	Brig. Gen. A. P. Howe, U. S. A.....	Topographical survey of northeast approaches to Washington city.
Sept. 10	Brig. Gen. G. Granger, U. S. A.....	Topographical survey of part of Mobile bay, Ala.
17	Navy Department.....	Topographical survey of coast of North Carolina, from Masonboro' inlet to Lockwood's Folly inlet.
22	Brig. Gen. A. P. Howe, U. S. A.....	Shore-line of New York bay with line of deepest water.
October 1	Navy Department.....	Topographical survey of coast of North Carolina, from Masonboro' inlet to Lockwood's Folly inlet.
4	Brig. Gen. G. Weitzel, U. S. A.....	Copy of a map of Cape Fear river, from its entrance to Wilmington, and the adjoining coast of North Carolina.
8	Comd. J. P. Bankhead, U. S. N.....	Topographical survey of Hutchinson island, St. Helena sound, S. C.
17	Admiral C. K. Stribling, U. S. N.....	Shore-line and hydrography of main entrance to Charlotte harbor, Fla.

APPENDIX No. 3.

Statistics of field and office work of the United States Coast Survey during the years—

	Previous to 1844.	From 1844 to 1848.	From 1849 to 1853.	From 1854 to 1858.	1859.	1860.	1861.	1862.	1863.	Tota..
Reconnaissance—										
Area, in square miles	9,642	13,599	20,363	9,918	1,782	6,050	555	716	134	53,147
Parties, number of, in each year	4	5	5	7	3	1	1	4	5	.....
Base lines—										
Primary, number of	1	4	2	3						10
Secondary, number of	2	3	19	23	5	2	1	2	1	58
Length of, in miles	194	38	49	50	6	1	1	1	1	165
Triangulation—										
Area, in square miles	9,076	8,641	13,445	12,806	3,724	4,773	1,632	1,514	567	56,968
Extent of general coast, in miles	570	738	1,058	1,389	358	532	173	152	.....	4,070
Extent of shore-line, in miles, including bays, sounds, islands, and rivers	1,588	3,498	5,143	7,761	2,092	1,617	1,200	1,061	.....	23,960
Horizontal angle stations occupied	750	615	992	1,937	344	322	150	168	181	5,438
Geographical positions determined	1,183	1,088	1,712	3,592	794	681	402	432	371	9,904
Vertical angle stations occupied	15	18	74	111	17	17	10	18	63	343
Elevations determined, number of	44	110	209	174	31	44	11	26	78	727
Parties, number of, in each year	4	8	14	19	21	21	14	12	12	.....
Astronomical operations—										
Stations occupied for azimuth	9	13	29	14	7	5	2	2	.....	86
Stations occupied for latitude	9	26	55	24	5	6	2	2	.....	129
Stations occupied for longitude	1	9	56	10	1	7	2	.....	.....	85
Permanent longitude stations .....	.....	6	20	10	1	1	1	1	1	41
Special longitude stations for occultations, &c. ....	.....	.....	.....	63	24	24	.....	2	1	111
Parties, number of, in each year	1	3	5	5	5	6	2	2	.....	.....
Magnetic stations occupied, number of .....	.....	86	51	49	18	19	6	6	8	243
Parties, number of, in each year .....	.....	3	3	4	4	7	4	2	4	.....
Topography—										
Area surveyed, square miles	6,131	2,514	3,072	3,523	657	592	577	424	171	17,661
Length of general coast, in miles	414	609	975	1,116	224	320	190	259	16	4,213
Length of shore-line, in miles, including rivers, creeks, and ponds .....	.....	.....	.....	13,862	2,660	2,052	1,737	1,240	626	44,302
Length of roads, in miles	11,734	4,788	2,749	4,640	482	200	1,232	1,249	537	27,691
Parties, number of, in each year	6	7	13	18	22	23	17	20	.....	.....
Hydrography—										
Parties, number of, in each year	2	6	10	11	9	9	9	13	.....	.....
Number of miles run while sounding	29,214	20,604	39,498	58,832	9,426	9,438	2,434	5,916	6,307	181,209
Area sounded out, square miles	9,601	5,068	11,431	13,617	4,310	1,651	225	611	735	47,239
Miles run additional, of outside or deep-sea soundings	1,800	3,470	5,407	14,534	2,353	2,375	.....	.....	.....	30,019
Soundings, number of	808,147	349,807	1,495,954	2,148,564	398,053	373,251	224,978	383,405	260,700	7,053,879
Soundings in Gulf Stream for temperature .....	.....	1,331	1,053	1,217	235	246	.....	.....	.....	4,072
Tidal stations, permanent .....	.....	9	21	40	10	11	7	7	7	.....

REPORT OF THE SUPERINTENDENT OF

APPENDIX No. 3—Continued.

	Previous to 1844.	From 1844 to 1848.	From 1849 to 1853.	From 1854 to 1858.	1859.	1860.	1861.	1862.	1863.	Total.
Hydrography—										
Tidal stations occupied temporarily.....	127	148	381	370	32	50	27	34	14	1,083
Tidal parties, number of, in each year.....	2	6	11	13	10	12	7	9	6	.....
Current stations occupied.....		923	226	281	38	84	44	7	9	1,012
Current parties, number of, in each year.....		4	6	4	2	1	2	1	1	.....
Specimens of bottom, number of.....	1,020	4,134	1,302	1,626	164	188	11			8,454
Records—										
Triangulation, originals, number of volumes.....	97	101	208	393	94	129	82	57	52	1,204
Astronomical observations, originals, number of volumes.....	17	63	220	233	27	33	13	17	3	634
Magnetical observations, originals, number of volumes.....	4	20	26	64	9	13	17	6	18	177
Duplicates of the above, number of volumes.....	27	183	296	632	77	111	103	53	35	1,487
Computations, number of volumes.....	78	112	294	483	88	115	66	34	46	1,509
Hydrographic soundings and angles, originals, volumes.....	188	408	906	1,536	306	194	159	86	171	3,634
Hydrographic soundings and angles, duplicates, volumes.....	28	33	82	101	19	10	4	2	6	285
Tidal and current observations, originals, volumes.....	127	205	531	633	75	64	39	37	16	1,777
Tidal and current observations, duplicates, volumes.....		206	773	407	55	54	15	16	13	1,541
Sheets from self-registering tide-gauges, number of.....			98	549	140	180	118	75	77	1,246
Tidal reductions, number of volumes.....			139	372	52	60	46	38	38	1,141
Total number of volumes of records.....	566	1,717	3,415	4,620	804	775	511	312	388	13,138
Maps and charts—										
Topographical maps, originals.....	168	104	194	273	45	47	33	44	23	931
Hydrographic charts, originals.....	142	74	195	263	41	37	16	32	35	835
Reductions from original sheets, number of.....	15	70	149	177	92	93	21	19	19	585
Total number of manuscript maps and charts.....	325	248	538	713	178	107	70	95		2,274
Number of sketches made in field and office.....	311	166	533	617	353	108	62	65	71	2,286
Engraving and printing—										
Engraved plates of finished charts, number of.....	5	19	23	25	8	8	9	6	6	109
Engraved plates of preliminary charts, sketches and diagrams for the Coast Survey reports, number of.....										
Electrotype plates made in each year.....		16	113	215	21	17	14	8	12	416
Finished charts published in each year.....		8	117	370	87	58	43	43	38	754
Preliminary charts and hydrographic sketches published.....		24	92	24	6	7	7	6	6	.....
Printed sheets of maps and charts distributed.....		8	103	169	15	15	31	34	15	.....
Printed sheets of ditto deposited with sale agents.....		6,330	21,664	42,801	10,486	4,092	13,004	36,373	25,629	160,389
Library—Number of volumes.....		12,563	21,030	11,072	3,384	2,145	733	4,448	3,615	50,100
Library—Cost of.....		635	1,462	1,016	174	159	163	91	126	3,856
Library—Cost of.....			\$26,712	\$10,138	\$1,832	\$1,729	\$2,522	\$894.93	\$1,822.87	\$51,680

GENERAL NOTE.

Parties.—An average number is given for the years previous to 1844. A party operating in more than one section during the year is counted but once.

Triangulation.—The extent of general coast is measured in general outline, including Delaware and Chesapeake, as well as all open bays, but omitting the minor indentations of the sea-coast. The extent of shore-line is also measured in general outline, and includes such rivers only as have been triangulated.

Topography.—The length of general coast is measured similarly to that under triangulation; but the shore-line under topography represents the whole water-line surveyed, including all the minor indentations, as represented on the plane-table sheets.

Records.—The total number of volumes of records given in the table is greater than the number now on hand, owing to the binding up of separate volumes.

Engraved plates.—Progress sketches (averaging fourteen yearly) are not counted.

Library.—The number of volumes purchased and donated up to 1849 was 655.

It is to be remarked that the numbers appearing in the column of this table for the year immediately preceding that of its compilation are, in some cases, subject to be changed, more or less, in the succeeding report, owing to data not being, at the time of compilation, fully turned into the offices from the distant parties in the field.

APPENDIX No. 4.

GENERAL LIST OF COAST SURVEY DISCOVERIES AND DEVELOPMENTS TO 1863. INCLUSIVE.

1. Examination of the channels leading into Carver's harbor, (Penobscot bay,) with reference to the positions of rocks and shoals dangerous to navigation, 1863.
2. A dangerous ledge determined in position, with only eleven feet at mean low water, two miles west of the north end of Metinic island, mouth of Penobscot bay, 1863.
3. A ledge with four fathoms of water on it, discovered S.S.W. $\frac{1}{4}$ W., (true,) and a mile and a quarter from Pemaquid light-house, coast of Maine, 1860.
4. Numerous dangerous reefs and ledges developed at the entrance and in the approaches of Damariscotta river, Maine, 1860.
5. Two rocks, one with three and a quarter fathoms, the other with only ten feet of water, and a ledge with three and a half fathoms, found in the channel of Booth bay, Maine, 1860.
6. Determination in position and depth of ten rocks near the approaches of Portland harbor, and of a spot with only fourteen feet water on Bulwark shoal; on Vapor Rock, twenty feet; on Witch Rock, twenty-four; on Corwin Rock, twenty-four and a half; on Mitchel Rock, thirty-one; on Willard Rock, thirty-one and a half; on Bache Rock, thirty-two feet; on Round Rock, thirty feet; on Old Anthony or Vapor Rock, twenty feet; on the Western Hue-and-Cry, twenty-seven and a half feet; on West Cod ledge, thirty-four feet; and on East Cod ledge, forty-nine feet; 1863.
7. Jeffrey's bank and Jeffrey's ledge, off the coast of Maine, thoroughly sounded out, 1860.
8. Only eighteen feet at mean low water found on the rock one mile to the southward of Seguin island, coast of Maine, 1859.
9. Temple's ledge, near Cape Small Point, Maine, 1857.
10. True position of the Hussey Rock, in Casco bay, determined, correcting the erroneous one assigned on previous charts, 1859.
11. Determination of the position of a sunken rock on which the steamer Daniel Webster struck, in Casco bay, on the evening of the 13th of October, 1856.
12. Determination of the dimensions of Alden's Rock, near Cape Elizabeth, Maine, 1854.
13. Determination of the position of the "Hue-and-Cry," the "Old Proprietor," and other dangers off Cape Elizabeth, Maine, 1859.
14. Huzzy's Rock, south of Fletcher's Neck, Maine, determined in position, 1859.
15. Development of a four-fathom bank off Cape Porpoise, Maine, 1859.
16. Fishing ledge, off Kennebunk, Maine, thoroughly sounded, 1859.
17. A rock one mile to the southward and westward of Boon island, with seventeen feet water; the sea breaks on it in heavy weather, 1858.
18. Development of a rock off Ogunquit, bare at low tides, and very little known, 1859.
19. Development of Boon Island ledge, coast of Maine, 1858.
20. A rock off Cape Neddick, Maine, determined in position, 1858.
21. A detached rock, two-thirds of a mile northward and eastward of York ledge, Maine, 1858.
22. Determination of the position of a rock more than a mile off the mouth of York river, Maine, bare at low tides and dangerous to coasters, 1858.
23. Development of Duck Island ledge, 1858.
24. A fishing bank sounded out off Wood island, coast of Maine, 1859.
25. A very dangerous rock, with only six and a half feet water, off the entrance to Portsmouth harbor, New Hampshire, about four nautical miles eastward from the Whale's Back light, 1858.
26. A rock with twelve feet at mean low water, about four miles and a third eastward of the Whale's Back, 1858.
27. Determination of the positions of four points of rock in Sandy bay, (Cape Ann.) Massachusetts, 1861.
28. A rock (not on any chart) in the inner harbor of Gloucester, Massachusetts, discovered in 1853.
29. Determination of rocks off Marblehead and Nahant, 1855.
30. Determination of the position of White Rock ledge, at the entrance of Saugus river, Massachusetts, 1860.

31. A bank ninety miles eastward of Boston, with about thirty-six fathoms of water, probably a knoll connected with Cashe's ledge, but with deep water between it and the ledge, 1853.
32. Boston harbor, Broad Sound channel thoroughly surveyed and marks recommended, 1848.
33. Several rocks in the fair channel-way in Boston harbor entrance, 1854.
34. An extension of the sand-pit to the southward of Sunken ledge, Boston harbor, since the survey of 1847; 1858.
35. Discovery of a rock with only seventeen feet of water at mean low tide in the Narrows of Boston harbor, 1860.
36. Special investigation of the currents of Boston harbor, 1860 and 1861.
37. A bank (Stellwagen's bank) with ten and a half to fourteen and a half fathoms of water on it, at the entrance to Massachusetts bay, and serving as an important mark for approaching Boston and other harbors, 1854.
38. Extension of Stellwagen's bank to the southward and eastward some sixteen or seventeen square miles, enclosed by the twenty-fathom curve, 1855.
39. Changes in the vicinity of East harbor, (Cape Cod,) 1857.
40. Special tidal and current observations at the mouth of Scusset river, (Cape Cod bay,) 1860.
41. A dangerous sunken ledge (Davis's ledge) to the eastward and in the neighborhood of Minot's ledge, 1854.
42. Development of a reef extending between Minot's and Scituate light, 1856.
43. A sunken rock, with only six feet on it at low water, off Webster's Flag-staff, Massachusetts bay, 1856.
44. A dangerous rock near Saquish Head, entrance to Plymouth harbor, 1856.
45. Three rocks determined in position, partly bare at low water, off Manomet Point, Massachusetts bay, 1856.
46. Determination of a very dangerous rock off Indian Hill, and four miles southward of Manomet Point, Massachusetts bay, with as little as six feet water on it, 1856.
47. The currents of Cap Cod bay observed with reference to their physical effects on the shores, 1861.
48. Determination of the position of a small rock with less than four feet at mean low water, near the channel and in the vicinity of Great Rock, Hyannis harbor, Massachusetts, 1859.
49. Probable connexion of George's bank and the deep-sea banks north and east of Nantucket, 1855.
50. The decrease of depth, with general permanence of form of George's bank, off the coast of Massachusetts, 1857.
51. A shoal spot near Little George's bank, 1857.
52. Non-existence determined of "Clark's bank" and "Crab ledge," laid down on certain charts as distinct from an immense shoal ground off Cape Cod peninsula, 1856.
53. Nantucket shoals; Davis's new South shoals, six miles South of the old Nantucket South shoals in the track of all vessels going between New York and Europe, or running along the coast from the eastern to the southern States, or to South America; discovered in 1846.
54. Two new shoals north and east of Nantucket; discovered in 1847.
55. Six new shoals near Nantucket, the outermost fourteen and a half miles from land, and with only ten feet water; discovered in 1848.
56. McBlair's shoals off Nantucket; discovered in 1849.
57. The tidal currents of Nantucket shoals and the approaches, 1854.
58. Davis's bank, Nantucket shoals; discovered in 1848, and survey finished in 1851.
59. Fishing Rip, a large shoal extending north and south, about ten miles to the eastward of Davis's bank, and thirty miles from Nantucket, with four and a half fathoms; surveyed in 1852.
60. A ridge connecting Davis's new South shoal and Davis's bank; found in 1853.
61. A small bank or knoll with but five fathoms on it, about five miles east of Great Rip, with twelve fathoms between it and Davis's bank and Fishing Rip, the water gradually deepening outside of it to the northward and eastward beyond the limits of the series of shoals, 1853.
62. Discovery of a shoal lying N.N.E., over six miles long, and twenty-four miles southeast of Davis's South shoal, with ten to ten and a half fathoms of water, 1860.
63. Discovery of three small banks off the Nantucket shoals in the vicinity of Phelps's bank, and further development of the extent of that shoal ground, 1861.
64. Discovery of Edwards's shoal, one mile and seven-eighths southward of Nantucket light-boat, 1855.

65. Examination of the interference tides of Nantucket and Martha's Vineyard sounds, 1855.
66. The study of the tidal currents of the Vineyard and Nantucket sounds, 1857.
67. Contraction of the inlet at the north end of Monomoy island, and opening of a new entrance to Chatham harbor, 1853.
68. Muskeget channel, surveyed by Lieutenant C. H. Davis in 1848, and Lieutenant C. H. McBlair in 1850.
69. Discovery of two shoal spots, with twelve and thirteen feet water, eastward from Great and Little Round shoals, Nantucket sound, 1856.
70. Determination of two shoal spots near the northern extremity of Davis's bank, with fourteen and eighteen feet water, 1856.
71. Further development of Edward's shoal, three-fourths of a mile from the southern Cross Rip, Nantucket sound, 1856.
72. Shoal sand ridges discovered northward of Great Point light, Nantucket sound, 1856.
73. Important changes in geographical feature at the southeastern end of Martha's Vineyard, Muskeget channel, 1856.
74. Numerous rocks in Martha's Vineyard sound, Long Island sound, and the various bays and harbors connected with them.
75. Several dangerous rocks and ledges developed in the approaches of Sippican harbor, (Buzzard's bay,) and others inside of the harbor, 1863.
76. Two rocks discovered in the approaches to Newport harbor, R. I. One of these has fourteen and a quarter feet of water on it at mean low tide; the other has seventeen feet at low water. Ten other rocks, before known, were determined in position, 1862.
77. Luddington Rocks determined in position, about ten yards apart, a mile and a half (nautical) southwest by compass from New Haven light, 1858.
78. Development of a ledge (Great Eastern ledge) off Montauk Point, having at one point only twenty-four feet at mean low water, and at another twenty-seven feet, 1863.
79. The tidal currents of Long Island sound, 1854.
80. The tidal currents of Hell Gate, 1857.
81. Least water on the Hell Gate Rocks determined by dragging, 1857.
82. Tidal currents in East river, New York, and surface and sub-currents investigated in New York harbor, the lower bay, and on the bar, 1858.
83. The currents of the great bay between Massachusetts, Rhode Island, Connecticut, New York, and New Jersey, 1855.
84. Gedney's channel, in New York bay, having two feet more water than the old channels. Had the true depth of this channel been known in 1778, (then probably existing, as seen by comparing old and new charts,) the French fleet, under Count D'Estaing, would have passed into the bay and taken the assembled British vessels, 1845.
85. The changes in New York harbor, near New York city, between 1845 and 1858.
86. Increase of depth in Buttermilk channel, ascertained and made known in 1848 by survey of Lieutenant D. D. Porter, United States navy.
87. The existence of a seventeen-foot spot on the shoal off the battery, New York harbor, the extension of the shoal towards the channel, and the shoaling of the water generally between the shoal and shore, 1859.
88. Shoal in the main ship channel of New York harbor, 1855.
89. The existence and character of sub-currents ascertained as bearing on the physical conditions of New York harbor, 1859.
90. The tides of Hudson river, 1856.
91. Sandy Hook: its remarkable increase traced from the surveys of the topographical engineers and others, and by several successive special surveys made between 1844 and 1863.
92. Development, by soundings, of a ridge lying sixteen miles off Barnegat, N. J., with eleven to thirteen fathoms of water, and sixteen fathoms between it and the coast, 1861.
93. The alteration of shore-line and sea encroachment near Absecon light-house, coast of New Jersey, 1863.
94. Special examination made and changes noted in the vicinity of the Five-fathom bank, off Cape May, 1861.

95. Development of hydrographic changes at the Delaware breakwater, 1863.
96. Delaware bay; Blake's channel at the entrance, discovered in 1844; open when the eastern channel is closed by ice. This discovery has served to develop strikingly the resources of that portion of Delaware.
97. Blunt's channel, in Delaware bay.
98. Changes in the Delaware, near the Pea Patch, 1847.
99. Hydrographic changes developed in the Delaware river, at the Bulk Head shoal, near Fort Delaware, at the bar off Fort Mifflin, and opposite to Philadelphia, 1861.
100. Special survey of part of League island, Delaware river, and comparison of changes with previous surveys, 1863.
101. Examination of soundings eastward of Winter Quarter shoal to determine the alleged existence of a second shoal, 1863.
102. The true extent and position of the dangerous shoals near Chincoteague inlet, Virginia, 1852.
103. Metomkin inlet, Virginia, shoaling from eleven to eight feet in the channel during 1852.
104. The shifting of the bar of Metomkin inlet, Virginia, and changes of shore-line, but without alteration of depth on the bar, 1862.
105. Two channels into Wachapreague inlet, Virginia—one from the northward, and the other from the eastward—both with seven feet water at low tide, 1852.
106. A shoal half a mile in extent, not put down on any chart, five and a half miles east from the north end of Paramore's island, Virginia. It has but four fathoms water on it, and nine fathoms around it, 1852.
107. Great Machipongo inlet, Virginia. Found to have a fine wide channel, with eleven feet water on the bar at low ebb and fourteen at high tide. Good anchorage inside, from two to eight fathoms. The best harbor between the Chesapeake and Delaware entrances; 1852.
108. Two shoals near the entrance to the Chesapeake—one four and three-quarters nautical miles SE. by E. from Smith's Island light-house, with seventeen feet water upon it; the other, E. by S., nearly seven and three-quarters miles from the same light, with nineteen and a half feet upon it; 1853.
109. Only three feet water upon the "Inner Middle," the shoal part of the Middle Ground, west of the "north channel," at the Chesapeake entrance, 1852.
110. A twenty-five-fathom hole, two and a half miles W.SW. from Tazewell triangulation point, eastern shore of the Chesapeake. All other charts give not more than sixteen fathoms in this vicinity.
111. A shoal at the mouth of the Great and Little Choptank, in Chesapeake bay, 1848.
112. The sounding and measurement of the bars in Rappahannock river, 1855.
113. The general permanence of the Bodkin channel and shoals in its vicinity, at the entrance of the Patapsco river, between 1844 and 1854.
114. Changes developed in the shore-lines at the entrance of Little Annemessex river, Chesapeake bay, 1859.
115. A shoal (New Point shoal) in Chesapeake bay, with sixteen feet water on it, southeast from New Point Comfort light-house, off Mobjack bay, 1854.
116. Re-examination of York spit, Chesapeake bay, and least water determined, (nine feet.) 1855.
117. York river, Va., as a harbor, 1857.
118. Development of the best line of water for crossing the Kettlebottom shoals, Potomac river, there being no well-defined channel, 1862.
119. Changes in depth and outline at Oregon inlet, N. C., 1862.
120. A reconnaissance of the Wimble shoals, near Nag's Head, coast of North Carolina, 1854.
121. Submarine range of hills beyond the Gulf Stream tracked from Cape Florida to Cape Lookout, 1855.
122. Deep water found on Diamond shoal, and a dangerous nine-feet shoal off Cape Hatteras, 1850.
123. A new channel, with fourteen feet water, into Hatteras inlet, formed during the year 1852, which is better and straighter than the old channel.
124. Changes at Hatteras and Ocracoke inlets, 1857.
125. Extent of the sea encroachment at Cape Hatteras, and changes found near Hatteras inlet, N. C., 1860 and 1861.
126. Special examination of the tides and currents, with reference to the hydrographic and shore-line changes at Hatteras inlet, N. C., 1862.
127. A shoal found with only fourteen feet of water, S. by E. $\frac{1}{2}$ E., and distant ten and a half miles from Cape Lookout light-house, 1863.

128. The general permanence in depth on the bar of Beaufort, N. C., with the changes of position of the channel, 1854.
129. Changes on the bar of Beaufort, N. C., 1857.
130. Development of the alteration in outline and depth at the entrance of Beaufort harbor, N. C., 1862.
131. The well-ascertained influence of prevailing winds in the movement of the bars at Cape Fear and New Inlet entrances, and the gradual shoaling of the main bar; the latter fact being of great importance to the extensive commerce seeking that harbor, 1853.
132. Changes in the main Western and New Inlet channels in Cape Fear, 1855.
133. Frying Pan shoals, off Cape Fear, N. C.; a channel of two and a half fathoms upwards of a mile wide, distant eleven nautical miles from Bald Head light-house across the Frying Pan shoals. A channel extending from three to four miles from the point of Cape Fear to eight or eight and a half miles from it, with sufficient water at low tide to allow vessels drawing from nine to ten feet to cross safely. A channel at the distance of fourteen nautical miles from Bald Head light-house, one mile wide, with three and a half to seven fathoms water on it. The Frying Pan shoals extend twenty nautical miles from Bald Head light-house, and sixteen, seventeen, and eighteen feet water is found seventeen and eighteen nautical miles out from the light, 1851.
134. Shoaling of Cape Fear River bar thoroughly examined for purposes of improvement, 1852.
135. Changes of shore-line and hydrography determined at the Cape Fear entrances, N. C., 1858.
136. Changes of the Cape Fear bars and channels, 1857.
137. Changes at the entrance of Winyah bay and Georgetown harbor, and the washing away of Light-house Point at the same entrance, 1853.
138. Less water found off Cape Roman, by preliminary examination, than has been heretofore assigned, 1859.
139. Re-examination, by soundings, of the Rattlesnake shoal, S. C., 1862.
140. Maffitt's new channel, Charleston harbor, with the same depth of water as the ship channel, 1850.
141. The changes in Maffitt's channel, Charleston harbor, S. C., from 1852 to 1857.
142. Increase of depth developed in Maffitt's channel, Charleston harbor, S. C., 1858.
143. Changes in the main ship channel, Charleston harbor, 1851.
144. Changes in the channels at the entrance of Charleston harbor, 1852.
145. The remarkable discovery of continuous deep-sea soundings off Charleston, and of soundings in the depth of between four and five hundred fathoms beyond the Gulf Stream, 1853.
146. Stono entrance, S. C., sounded, and channel found half a mile to westward of its former position, with slight increase of depth, 1862.
147. Development of the changes affecting the entrance to North Edisto river, S. C., 1856.
148. The shoaling of North Edisto entrance from its former depth, to nine feet of water.
149. St. Helena entrance, S. C., examined, and a new channel from the eastward found, giving sixteen feet at mean low water, 1862.
150. Greater depth found through the channel of Coosaw river, S. C., (inland passage,) than has been hitherto supposed to exist, 1860.
151. Discovery of a new channel between Martin's Industry (shoal) and the southeast breakers, Port Royal entrance, S. C., 1856.
152. The south channel of Port Royal sound developed, and nineteen and a half feet found to be the least depth of water, 1862.
153. The channel of the inland passage thoroughly sounded, leading from Port Royal sound to Tybee roads, through Skull creek and Calibogue sound, 1862.
154. Discovery of cold water at the bottom of the ocean below the Gulf Stream, along the coast of North and South Carolina, Georgia, and Florida, 1853.
155. The discovery of the cold wall, alternate warm and cold bands, and various other features of the Gulf Stream, especially such as concern its surface and deep-sea temperatures, and its distribution relative to the shore and bottom of the ocean.
156. Various facts relative to the distribution of minute shells on the ocean bottom, of probable use to navigators for recognizing their positions.
157. Changes in shore-line and in depth observed in Ossabaw sound, Ga., 1860.
158. A new channel developed leading into Sapelo sound, Ga., three-quarters of a mile southward, and better than the one in use, 1860.

159. Examination of Doboy, St. Simon's, and Cumberland entrances, 1855.
160. The bar and entrance of St. Simon's sound, Ga., examined, showing no material change of depth within the past two years, 1862.
161. The shifting to southward and shoaling by several feet of the channel into Fernandina harbor, Fla., having now only eleven feet at mean low water, 1862.
162. A shoal inside of the entrance to Amelia river, Fla., 1857.
163. Hetzel shoal, off Cape Canaveral, Fla., 1850.
164. A shoal spot found off the coast of Florida, ten miles from land and fifteen miles NE. of Indian River inlet, 1860.
165. Temperature of 34° beneath the Gulf Stream, thirty-five miles east of Cape Florida, at a depth of three hundred and seventy fathoms, 1855.
166. Further explorations and investigations in developing the character of the Gulf Stream in the Florida channel, 1859 and 1860.
167. A harbor of refuge (Turtle harbor) to the northward and westward of Carysfort light-house, Florida reef, with a depth of water of twenty-six feet at the entrance, 1854.
168. A new passage, with three fathoms water, across the Florida reef, to Legaré harbor, under Triumph reef, (latitude $25^{\circ} 30' N.$, longitude $80^{\circ} 03' W.$) which, if properly buoyed, will be valuable as a harbor of refuge, 1852.
169. A safe rule for crossing the Florida reef near Indian key, 1854.
170. Tennessee shoal, Florida reef, developed, giving only twelve feet of water on its outer patch, 1860.
171. The position of a sunken wreck determined and marked, lying off Grassy key, Florida reef, and near the track of vessels, 1860.
172. A new channel into Key West harbor, 1850.
173. Co-tidal lines for the Atlantic coast of the United States, 1854.
174. Rules for navigators in regard to the tidal currents of the coast, 1857.
175. Isaac shoal, near Rebecca shoal, Florida reef; not laid down on any chart; 1852.
176. Channel No. 4, a northeast entrance into Cedar Keys bay, 1852.
177. Directions for entering the harbor from Crystal River offing, west coast of Florida peninsula, 1856.
178. A new channel discovered, leading into St. George's sound, (Apalachicola, Fla.,) at the east end of Dog island, and anchorage connected with it, 1858.
179. Shoals near the east and west passes of St. George's sound, (Apalachicola, Fla.,) and a new channel found between St. George's and St. Vincent's islands, 1858.
180. Indications noticed of a deeper and better channel forming to lead to the East Pass anchorage, St. George's sound, Fla., 1850.
181. Changes in the depth of water observed by comparison of soundings at Perdido entrance, 1860.
182. Mobile Bay Entrance bar; in 1832 only seventeen feet at low water could be carried over it; in 1841 it had nineteen, and in 1847 it had twenty feet and three quarters, as shown by successive surveys; 1847.
183. The diminution, almost closing, of the passage between Dauphine and Pelican islands, at the entrance of Mobile bay, 1853.
184. The currents of Mobile bay specially investigated, 1860.
185. Horn Island channel, Mississippi sound, 1852.
186. The removal of the east spit of Petit Bois island in the hurricane of 1852, opening a new communication between the Gulf and Mississippi sound, and the rendering of Horn Island Pass more easy of access by the removal of knolls, 1853.
187. The accurate determination of Ship shoal, off the coast of Louisiana, in connexion with the site for a light-house, 1853.
188. An increase of depth of water on the bar of Pass Fourchon, La., 1854.
189. Deep-sea soundings in the Gulf of Mexico, 1855-'56.
190. Tidal phenomena of the Gulf, 1855.
191. The changes at Aransas Pass, Texas, as bearing on the question of a light-house site, 1853.
192. Co-tidal lines of the Gulf of Mexico, 1856.
193. On the effect of wind in disturbing the tides of the Gulf of Mexico, 1856.
194. Development of a bar at the entrance of San Diego bay, Cal., 1856.
195. A shoal inside of Ballast Point, San Diego bay, with only twelve and a half feet of water, not laid down on any chart, 1852.

196. The determination of the position and soundings on Cortez bank, off the coast of California, 1853.
197. Complete hydrographic survey and determination of a point of rock on Cortez shoal, 1856.
198. Tides of San Diego, San Francisco, and Astoria, 1854.
199. The non-existence of San Juan island, usually laid among the Santa Barbara group, 1852.
200. Co-tidal lines of the Pacific coast, 1855.
201. Determination of Uncle Sam Rock, 1855.
202. Investigation of the currents of Santa Barbara channel, 1856.
203. Development in position of the point with only twenty-one feet at mean low water, of Noonday Rock, (called also Fanny shoal,) in the track of vessels passing the North Farallon, approaching San Francisco bay, 1863.
204. Red sand marking the entrance to the Golden Gate, 1855.
205. Determination of the position of the wreck of the ship Flying Dragon, in the track of vessels navigating San Francisco bay, 1863.
206. Channel sounded out between Yerba Buena and the Contra Costa, San Francisco bay, 1855.
207. A reef developed off the Contra Costa flats, San Francisco bay, Cal., 1858.
208. Whiting's Rock determined in position, near the "Brothers," at the entrance of San Pablo bay, Cal., 1858.
209. The further encroachment of the sand-spit at the confluence of Karquines and Mare Island straits upon the channels which lead to the navy yard and to Benicia, 1862.
210. Further development of the extent of Commission Rock, San Pablo bay, 1856.
211. Changes in the channel entrance of Humboldt bay or harbor, Cal., 1852 and 1853.
212. South channel, Columbia river, surveyed and made available to commerce, 1851. Changes of channels, their southward tendency, and a new three-fathom channel from Cape Disappointment due west to open water, Columbia entrance, 1852. Further changes, 1853.
213. The depth of water on the bars at the entrance of Rogue river and Umpquah river, Oregon, 1853.
214. A shoal at the northern entrance to the strait of Rosario, W. T., giving good holding-ground in thirty-three feet, 1854.
215. Boulder reef, northwest of Sinclair island, Rosario strait, partly bare at unusually low tides, and surrounded by kelp, 1854.
216. A bank of three and a half fathoms, about a mile off the southwest point of Sucia island, at the northern entrance of Washington sound, W. T., 1858.
217. Belle Rock, in the middle of Rosario strait, visible only at extreme low tides, 1854.
218. Entrance Rock, at the entrance of Rosario strait, 1854.
219. Unit Rock, in the Canal de Haro, W. T., visible only at extreme low tides, 1854.
220. A three-fathom shoal in the strait of Juan de Fuca, off the southeast part of Bellevue or San Juan island, 1854.
221. Allen's bank, Admiralty inlet, W. T., 1857.
222. A five-fathom shoal in the strait of Juan de Fuca, between Canal de Haro and Rosario strait, 1854.
223. A bank in eleven fathoms off the southern entrance to Canal de Haro, 1854.
224. The non-existence of two islands at the northern entrance of Canal de Haro, laid down on charts, 1853.
225. Various surveys and charts of small harbors on the Pacific coast of the United States, and a continuous reconnaissance of the entire Western Coast and islands adjacent, a great part of which was imperfectly known.
226. Winds of the Western Coast of the United States, 1857.

ADDITIONAL LIST FOR 1864.

1. Determination of the position of Birch Point ledge, with eleven feet of water on it in Wiscasset bay, and of a rock with only four feet, near Clou's ledge, in Sheepscot river, Maine.
2. White Head Ground, about eight miles to the eastward of Cape Elizabeth, Maine, developed in its general direction.
3. A rock in the entrance to New Bedford Harbor, Massachusetts, determined in position.
4. Development of Round shoal, with eleven feet at mean low water, outside of the four-fathom curve off Absecom inlet, New Jersey.
5. Hatteras inlet: the character and extent of recent changes in the depth of water determined by resurveys.

6. Three separate shoals developed by reconnaissance to the southward and eastward of Cape Lookout, North Carolina.
7. Beaufort harbor, North Carolina, re-examined and its hydrographic changes determined.
8. Two new channels developed, leading into Charleston harbor, South Carolina, resulting from changes in the direction of the former channels, and shoaling in the Lawford channel.
9. Hydrographic changes determined at the bar and in the channel of St. John's river, Florida.
10. Mare Island strait resurveyed, and changes developed in the vicinity of the navy yard.
11. Special examination of the flat in San Pablo bay, between San Pablo and Pinole Point.

APPENDIX No. 5.

REPORT BY LIEUTENANT COMMANDER T. S. PHELPS, UNITED STATES NAVY, ASSISTANT COAST SURVEY, ON HIS RECONNAISSANCE OF THE CAPE LOOKOUT SHOALS OFF THE COAST OF NORTH CAROLINA.

UNITED STATES COAST SURVEY STEAMER CORWIN,
Portland, Maine, September 1, 1864.

SIR: I have respectfully to report on a reconnaissance of the Cape Lookout shoals, North Carolina. A survey of this ground, at this season of the year, I found impossible, owing to the constant strong winds and heavy sea which prevail after the middle of June, from April to the above period being, I am informed, about the only season in which a survey can be successfully accomplished on this part of the coast.

During the few days on which I could execute any work the boats could not be used, and I found it too hazardous (having struck in fourteen feet water) to run the steamer where the color of the water indicated three fathoms or less.

The breakers make S. by E. $\frac{1}{4}$ E., seven and a half miles from the light-house, and are constant with the exception of a space of about two and a half miles, where in moderate weather the sea does not break; and I was informed by the light-house keeper that this space was used by vessels drawing less than nine feet.

From the south point of the constant breakers the shoal continues in the same direction three miles further, or ten and a half miles S. by E. $\frac{1}{4}$ E. from the light-house. This part of the shoal is indicated by light-green water, varying to a yellow tinge on the shoalest lumps; and is also very "lumpy," the water over the lumps varying in depth from about nine to eighteen feet, and it is on this point south of the constant breakers that the blockade vessels have recently touched. About one mile and a half to the southward and eastward of the above shoal is one on which there is five and a half fathoms water, and still further in the same direction, S.E. by S. $\frac{1}{2}$ S., thirteen and a half miles from the light-house, lies the outer shoal, on which there is five and a quarter fathoms. Beyond this I discovered no indications of shoals. With the eye elevated thirteen feet above the water, and ten and a half miles from the light-house, just clear of the dangerous shoal, the ground on which the light-house stands is below, and the lower red stripe of the old light-house is half its width above the horizon; the constant breakers are plain in sight three miles distant.

The lower red stripe, well on the horizon, will carry a vessel around the dangerous shoal in from six to eight fathoms.

On the five and a half fathom shoal the breakers are in sight, with no horizon showing beyond, and when on the outer shoal, in five and a quarter fathoms, the lower edge of the upper red stripe of the old light-house is a little above the horizon, and there are no breakers in sight. With the top of the old light-house just discernible above the horizon, a vessel will be well clear of all shoals, and fifteen miles from the light-house. In from seven to eleven fathoms the color of the water is dark green; in five fathoms a pale green; and in three fathoms and less a very light green, varying according to the depth.

I am, very respectfully, your obedient servant,

THOMAS S. PHELPS,

Lieutenant Commander U. S. Navy, Assistant Coast Survey.

Prof. A. D. BACHE, LL.D.,

Superintendent United States Coast Survey, Washington, D. C.

APPENDIX No. 6.

EXTRACTS FROM THE REPORT OF ACTING ASSISTANT EDWARD CORDELL, DESCRIBING HYDROGRAPHIC CHANGES AT BEAUFORT ENTRANCE, NORTH CAROLINA.

BEAUFORT, N. C., *May 2, 1864.*

SIR: I have the honor to report the completion of the resurvey of the entrance to this harbor, from sea to Fort Macon, in accordance with your instructions of March 21. The buoys have been placed so as to mark the line of best water in the channel, and in conformity with the changes that have taken place since the last survey was made. The work was commenced on the 7th of April, and continued up to date. The principal changes in the channel occur at Black buoy, No. 3. It was placed in 1862 in twenty feet of water to mark the point of the southwest breakers. Since then the breakers have extended to the westward about one hundred yards beyond the original position of the buoy, and but eight feet of water was found at its position. It was removed into sixteen feet.

Abreast of Red buoy, No. 4, in mid-channel, a bank has formed with twelve feet of water upon it. Its extent is about four hundred yards in a northwest and southeast direction, with thirteen feet on its eastern and thirteen and a half on its western side. To indicate its position for vessels entering this port, I have shifted buoy No. 4 from the eastern edge of the channel to the west side of the bank into fourteen feet water. By changing the position of Black buoy No. 5 to the southward and eastward to mark a twelve feet spot on the west edge of the channel, the buoying of the best line of water in the channel has been effected.

According to the new survey, fourteen feet was the least water found on the outer bar, and thirteen and a half the best on the inner bar at mean low water. The mean rise and fall of the tides is three feet.

Referring to the chart you will perceive considerable change in the shore line at the northwest point of Shakelford island. A strong current at the mouth of Core sound is washing away that point, and is probably the cause of the formation of the bank in mid-channel, and the making of a new channel to the southward of Black buoy No. 7.

This new channel, as well as the upper part of the harbor, also, will be thoroughly examined during the present month. * * * In conclusion, I would express my acknowledgments to Commander Dove, of the navy, for his cheerful co-operation and promptness in furnishing means and facilities to carry out your instructions.

Very respectfully, your obedient servant,

EDWARD CORDELL.

Prof. A. D. BACHE,

Superintendent United States Coast Survey, Washington, D. C.

APPENDIX No. 7.

EXTRACTS FROM THE REPORT OF ACTING ASSISTANT EDWARD CORDELL, RELATIVE TO THE SURVEY OF CORE SOUND, NORTH CAROLINA.

UNITED STATES SCHOONER LENOX,

New Bern, September 9, 1864.

SIR: I have the honor to report the completion of the hydrographic survey of the channel leading through the Straits and Core sound, from Beaufort harbor into Pamlico sound, North Carolina. Five feet of water were found on Harbor Island bar, which depth can also be carried over the shoalest places in the channel through the sound. Southerly winds depress this depth to four feet seven inches, while northerly and easterly winds increase it to nearly six feet. The entrance and bar at Harbor island have been marked by three iron can buoys, painted white and black, in perpendicular stripes. The outer buoy, a second-class can, was placed in seventeen feet of water, sticky bottom, one-fourth of a mile outside the bar; southwest of it three-eighths of a mile is the bar buoy, a third-class can, in five and a half feet; and S. W. by W. $\frac{1}{2}$ W., one-half mile from it, lies the inner buoy in eight and a half feet of water, nearly in the position of the former light-vessel. From here the channel was marked by hand stakes, marking the points of shoals and pointing to

the best water, and by running or bush stakes placed at convenient distances from each other in mid-channel. The number of stakes from Beaufort to Harbor island is 135. The entrance into the straits from Beaufort will be marked by a spar-buoy as soon as possible. The mean rise and fall of tides in the straits is one foot and a half nearly; at the entrance of the straits into Core sound, one foot; and at Piney Point, about half-way between Beaufort and Harbor island, four-tenths of a foot. At Harbor island it is barely perceptible.

The current in the sound is feeble, and principally caused by the prevailing winds. * * * * *

Very respectfully, your obedient servant,

EDWARD CORDELL,

Acting Assistant United States Coast Survey.

Prof. A. D. BACHE,

Superintendent United States Coast Survey, Washington, D. C.

APPENDIX No. 8.

TIDE TABLES FOR THE USE OF NAVIGATORS, PREPARED FROM THE COAST SURVEY OBSERVATIONS BY A. D. BACHE, SUPERINTENDENT.

[Furnished, by authority of the Treasury Department, to E. and G. W. Blunt, New York, and revised—1864.]

The following tables will enable navigators to ascertain the time and height of high and low water in some of the principal ports of the United States. The results are approximate, the observations being still in progress, and the period of several of them steadily on the increase as the coast survey advances.

The tides on the coast of the United States, on the Atlantic, Gulf of Mexico, and Pacific, are of three different classes. Those of the Atlantic are of the most ordinary type, ebbing and flowing twice in twenty-four hours, and having but moderate differences in height between the two successive high waters or low waters—one occurring before noon, the other after noon.

Those of the Pacific coast also ebb and flow twice during twenty-four hours, but the morning and afternoon tides differ very considerably in height—so much so that at certain periods a rock which has three feet and a half water upon it at low tide may be awash on the next succeeding low water. The intervals, too, between successive high and successive low waters may be very unequal.

The tides of ports in the Gulf of Mexico, west of Cape St. George, ebb and flow, as a rule, but once in twenty-four hours, or are single-day tides. At particular parts of the month there are two small tides in the twenty-four hours. The rise and fall in all these ports is small. East of Cape St. George the rise and fall increases; there are two tides, as a rule, during the twenty-four hours, and the daily inequality referred to in the Pacific tides is large.

These peculiarities require a different way of treating the cases, and in some of them separate tables.

I propose to enable the navigator to find, from the Nautical Almanac and the following tables, the time and height of high and low water at any date within the ordinary range of difference produced by winds and other variable circumstances. I will endeavor to divest the matter of unfamiliar technical expressions as far as practicable, though, for shortness' sake, some such terms may be employed after defining them. The discussion of the Gulf tides has not been carried so far as to enable me to present the results in as definite a form as the others.

As is well known, the interval between the time of the moon's crossing the meridian (moon's transit) and the time of high water at a given place is nearly constant; that is, this interval varies between moderate limits, which can be assigned. The interval at full and change of the moon is known as the establishment of the port, and is ordinarily marked on the charts. As it is not generally the average of the interval during a month's tides, it is a less convenient and less accurate quantity for the use of the navigation than the average interval which is used on the Coast Survey charts, and is sometimes called the "mean" or "corrected establishment."* The following table gives the principal tidal quantities for the different ports named in the

* This term was introduced by the Rev. Dr. Whewell, who has done so much for the investigation of the laws of the tides.

first column, where they are arranged under specific heads. The third column of the table gives the mean interval, in hours and minutes, between the moon's transit and the time of high water next after the transit; the fourth, the difference between the greatest and the least interval occurring in different parts of the month, (lunar.) A simple inspection of this column will show how important it is to determine these changes in many of the ports where they amount to more than half an hour, or to more than fifteen minutes from the average interval. The fifth, sixth, and seventh columns refer to the height of the tide. The fifth gives, in feet, the average rise and fall, or average difference between high and low water; the sixth gives the greatest difference, commonly known as the rise and fall of spring tides; and the seventh the least difference, known as the rise and fall of the neap tides.

The average duration of the flood or rising tide is given in the eighth column; of the ebb or falling tide in the ninth; and of the period during which the tide neither rises nor falls, or the "stand," in the tenth. The duration of the flood is measured from the middle of the stand at low water to the middle of the stand at high water, so that the whole duration from one high water to the next, or from one low water to the next, should be given by the sum of the numbers in the eighth and ninth columns. At most of these places given in the list a mark of reference has been established for the height of the tide. I have omitted the description of these marks, (except in the following localities,) as of no particular interest in this connexion.

BENCH-MARKS.

Boston.—The top of the wall or quay at the entrance of the dry dock in the Charlestown navy yard is fourteen feet $\frac{69}{100}$ (or 14.69 feet) above mean low water.*

New York.—The lower edge of a straight line cut in a stone wall at the head of a wooden wharf on Governor's island is thirteen feet $\frac{97}{100}$ (or 13.97 feet) above mean low water. The letters U. S. C. S. are cut in the same stone.

Old Point Comfort, Va.—A line cut in the wall of the light-house, one foot from the ground, on the southwest side, is eleven feet (11 feet) above mean low water.

Charleston, S. C.—The outer and lower edge of embrasure of gun No. 3, at Castle Pinckney, is ten feet $\frac{13}{100}$ (10.13 feet) above mean low water.

TABLE I.—Tide table for the coast of the United States.

PORT.	STATE.	INTERVAL BETWEEN TIME OF MOON'S TRANSIT AND TIME OF HIGH WATER.		RISE AND FALL.			MEAN DURATION OF—		
		Mean interval.	Difference between greatest and least interval.	Mean.	Spring tides.	Neap tides.	Flood tide.	Ebb tide.	Stand.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
COAST FROM PORTLAND TO NEW YORK.		<i>h. m.</i>	<i>h. m.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>
Eastport	Maine	11 8	0 51	18.1	20.6	15.4	6 3	6 23	.....
Hanniwell's Point, Kennebec river	do	11 15	1 14	8.1	9.3	7.0	6 16	6 11	0 22
Portland	do	11 25	0 44	8.9	9.9	7.6	6 14	6 12	20
Portsmouth	New Hampshire	11 23	53	8.6	9.9	7.2	6 22	6 7	21
Newburyport	Massachusetts	11 22	50	7.8	9.1	6.6	5 16	7 0	24
Rockport	do	10 57	42	8.6	10.2	7.1	6 17	6 9	30
Salem	do	11 13	50	9.2	10.6	7.6	6 19	6 6	6
Boston light	do	11 12	35	9.3	10.9	8.1	6 20	6 6	15
Boston	do	11 27	43	10.0	11.3	8.5	6 13	6 13	9
Plymouth	do	11 19	51	10.2	11.4	9.0	6 13	6 17	29
Wellfleet	do	11 5	1 13	11.2	13.2	9.2	6 6	6 17	15
Provincetown†	do	11 22	40	9.2	10.8	7.7	6 16	6 10	21
Monomey	do	11 58	37	3.8	5.3	2.6	6 25	5 59	36
Nantucket	do	12 24	37	3.1	3.6	2.6	6 23	5 44	9

* In consequence of alterations made to the wall during the year 1860 the coping is seven-hundredths of a foot lower than formerly.

† From Major J. D. Graham's observations.

REPORT OF THE SUPERINTENDENT OF

TABLE I—Continued.

PORT.	STATE.	INTERVAL BETWEEN TIME OF MOON'S TRANSIT AND TIME OF HIGH WATER.		RISE AND FALL.			MEAN DURATION OF—		
		Mean interval.	Difference between greatest and least interval.	Mean.	Spring tides.	Neap tides.	Flood tide.	Ebb tide.	Stand.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
PORTLAND TO NEW YORK—Continued.									
		<i>h. m.</i>	<i>h. m.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>
Hyannis	Massachusetts	12 22	30	3.2	3.9	1.8	6 44	5 41	9
Edgartown	do.	12 16	34	2.0	2.5	1.6	6 51	5 29	24
Holmes's Hole	do.	11 43	31	1 7	1.8	1.3	6 41	5 21	12
Tarpanlin Cove	do.	8 4	49	2.3	2.8	1.8	6 9	6 17	34
Wood's Hole, north side	do.	7 59	53	4.0	4.7	3.1	6 51	5 31	38
Wood's Hole, south side	do.	8 34	45	1.6	2.0	1.2	5 17	7 10	59
Menemsha Bight	do.	7 45	1 0	2.7	3.9	1.8	6 14	6 14	4
Quick's Hole, north side	do.	7 31	1 15	3.7	4.3	2.9	6 31	5 54	39
Quick's Hole, south side	do.	7 36	1 10	3.1	3.8	2.3	6 29	5 55	40
Cuttyhunk	do.	7 40	49	3.5	4.2	2.9	6 31	5 54	39
Kettle Cove	do.	7 48	1 0	4.3	5.0	3.7	6 17	6 4	29
Bird Island light	do.	7 59	45	4.4	5.3	3.5	6 51	5 58	.....
New Bedford entrance, (Dumpling Rock)	do.	7 57	41	3.8	4.6	2.8	6 50	5 33	42
Newport	Rhode Island	7 45	24	3.9	4.6	3.1	6 21	6 3	23
Point Judith	do.	7 32	46	3.1	3.7	2.6	6 12	6 10	1 0
Block Island	do.	7 36	41	2.8	3.5	2.0	6 23	6 2	5
Montauk Point, L. I.	New York	8 20	1 11	1.9	2.4	1.8	6 17	6 7	31
Sandy Hook	do.	7 29	47	4.8	5.6	4.0	6 10	6 15	21
New York	do.	8 13	43	4.3	5.4	3.4	6 0	6 25	28
HUDSON RIVER.									
Dobb's Ferry	New York	9 19	44	3.6	4.4	2.7	6 5	6 18	17
Tarrytown	do.	9 57	58	3.5	4.0	2.7	6 6	6 20	43
Verplanck's Point	do.	10 8	34	3.1	3.8	2.5	5 25	7 12	16
West Point	do.	11 2	37	2.7	3.2	2.0	5 28	7 10	20
Poughkeepsie	do.	12 34	54	3.2	3.9	2.4	5 41	6 44	22
Tivoli	do.	1 24	51	4.0	4.6	3.2	5 40	6 54	25
Stuyvesant	do.	3 23	48	3.8	4.4	3.0	5 18	7 2	31
Castleton	do.	4 29	55	2.7	3.0	2.3	5 1	7 23	20
Greenbush	do.	5 22	40	2.3	2.5	1.9	4 26	7 59	.....
LONG ISLAND SOUND.									
Watch Hill	Rhode Island	9 0	23	2.7	3.1	2.4	6 35	5 56	14
Stonington	Connecticut	9 7	30	2.7	3.2	2.2	6 15	6 10	25
Little Gull Island	New York	9 36	1 7	2.5	2.9	2.3	6 1	6 21	37
New London	Connecticut	9 28	52	2.6	3.1	2.1	5 56	6 26	22
New Haven	do.	11 16	1 8	5.9	6.2	5.2	6 24	6 5	33
Bridgeport	do.	11 11	1 3	6.5	8.0	4.7	6 1	6 7	30
Oyster Bay, L. I.	New York	11 7	51	7.3	9.2	5.4	6 8	6 24	25
Sand's Point, L. I.	do.	11 13	31	7.7	8.9	6.4	5 55	6 30	14
New Rochelle	do.	11 22	32	7.6	8.6	6.6	5 51	6 35	12
Throg's Neck	do.	11 20	39	7.3	9.2	6.1	5 50	6 33	43
COAST OF NEW JERSEY.									
Cold Spring inlet	New Jersey	7 32	0 51	4.4	5.4	3.6	6 8	6 18	19
Cape May landing	do.	8 19	47	4.8	6.0	4.3	6 11	6 15	20
DELAWARE BAY AND RIVER.									
Delaware breakwater	Delaware	8 0	50	3.5	4.5	3.0	6 15	6 6	26
Higbee's, Cape May	New Jersey	8 33	43	4.9	6.2	3.9	6 26	6 0	19
Egg Island light	do.	9 4	51	6.0	7.0	5.1	5 52	5 27	36
Mahon's river	Delaware	9 52	48	5.9	6.9	5.0	6 11	6 11	26
New castle	do.	11 53	24	6.5	6.9	6.0	5 6	5 43	47
Philadelphia	Pennsylvania	13 44	44	6.0	6.8	5.1	4 52	7 6	15
CHESAPEAKE BAY AND RIVERS.									
Old Point Comfort*	Virginia	8 46	52	2.5	3.0	2.0	6 1	6 25	14
Point Lookout	Maryland	12 58	45	1.4	1.9	0.7	5 59	6 19	35

* The mean interval has been corrected from later and more reliable observations.

TABLE I—Continued.

PORT.	STATE.	INTERVAL BETWEEN TIME OF MOON'S TRANSIT AND TIME OF HIGH WATER.		RISE AND FALL.			MEAN DURATION OF—		
		Mean interval.	Difference between greatest and least interval.	Mean.	Spring tides.	Neap tides.	Flood tide.	Ebb tide.	Stand.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
CHESAPEAKE BAY AND RIVERS—Cont'd.									
Annapolis	Maryland	<i>h. m.</i> 17 4	<i>h. m.</i> 40	<i>Fect.</i> 0.9	<i>Fect.</i> 1.0	<i>Fect.</i> 0.8	<i>h. m.</i> 6 11	<i>h. m.</i> 6 15	<i>h. m.</i> 32
Bodkin light	do.	18 8	48	1.0	1.3	0.8	5 23	7 8	15
Baltimore	do.	18 59	44	1.3	1.5	0.9	5 54	6 33	44
Washington	District of Columbia ..	20 10	52	3.0	3.4	2.6	5 37	6 49	.....
James river, (City Point) ..	Virginia	14 37	1 0	2.8	3.0	2.5	5 14	6 58	32
Richmond	do.	16 54	1 6	2.9	3.4	2.3	4 53	7 31	35
Tappahannock	do.	13 8	46	1.6	1.9	1.3	5 21	7 6	.....
COAST OF NORTH AND SOUTH CAROLINA, GEORGIA, AND FLORIDA.									
Hatteras inlet	North Carolina	7 4	57	2.0	2.2	1.8	6 7	6 7	50
Beaufort	do.	7 26	50	2.8	3.3	2.2	6 11	6 10	42
Bald Head	do.	7 26	34	4.3	5.0	3.4	6 18	6 17	31
Smithville	do.	7 19	38	4.5	5.5	3.8	6 1	6 26	26
Wilmington	do.	9 6	1 0	2.7	3.1	2.2	4 45	7 40	30
Georgetown entrance	South Carolina	7 56	42	3.8	4.7	2.7	6 4	6 19	35
Bull's Island bay	do.	7 16	57	4.8	5.7	3.7	6 20	6 6	30
Charleston, (custom-house wharf) ..	do.	7 26	48	5.1	6.0	4.1	6 19	6 7	33
St. Helena sound	do.	7 8	1 0	5.9	7.4	4.4	6 13	6 12	23
Fort Pulaski, (Savannah entrance) ..	Georgia	7 20	40	7.0	8.0	5.9	5 49	6 35	26
Savannah, (dry-dock wharf) ..	do.	8 13	51	6.5	7.6	5.5	5 4	7 22	14
Doboy light-house	do.	7 33	55	6.6	7.8	5.4	6 2	6 20	.....
St. Simon's	do.	7 43	46	6.8	8.2	5.4	6 10	6 16	20
Fort Clinch	Florida	7 53	1 6	5.9	6.7	5.3	6 9	6 17	.....
St. John's river	do.	7 28	48	4.5	5.5	3.7	5 58	6 28	16
St. Augustine	do.	8 21	43	4.2	4.9	3.6	6 5	6 11	32
Cape Florida	do.	8 34	51	1.5	1.8	1.2	6 0	6 26	45
Indian key	do.	8 23	49	1.8	2.2	1.3	6 25	5 59	19
Sand key	do.	8 40	.....	1.2	2.0	0.6	6 31	5 55	13
Key West	do.	9 30	1 15	1.3	1.5	0.9	6 55	5 29	12
Tortugas	do.	9 56	1 32	1.2	1.5	0.6	6 43	5 40	.....
Charlotte harbor	do.	13 9	1 38	1.1	1.3	0.8	6 51	5 35	.....
Tampa Bay, (Egmont key) ..	do.	11 21	1 33	1.4	1.8	1.0	6 36	6 11	43
Cedar Keys, (Depot key) ..	do.	13 15	1 55	2.6	3.2	1.6	6 12	6 13	.....
St. Mark's	do.	13 38	2 0	2.2	2.9	1.4	6 12	6 11	.....
WESTERN COAST.									
San Diego	California	9 38	1 35	3.7	5.0	2.3	6 22	6 0	30
San Pedro	do.	9 39	1 48	3.7	4.7	2.2	6 18	6 5	30
Cuyler's harbor	do.	9 25	1 2	3.7	5.1	2.8	6 13	6 5	.....
San Luis Obispo	do.	10 8	1 52	3.6	4.8	2.4	6 25	5 58	.....
Monterey	do.	10 22	49	3.4	4.3	2.5	6 31	6 2	35
South Farallon	do.	10 37	1 16	3.6	4.4	2.8	6 18	6 9	.....
San Francisco, (north beach) ..	do.	12 6	1 4	3.6	4.3	2.8	6 39	5 51	34
Mare island, (San Francisco bay) ..	do.	13 40	1 15	4.8	5.2	4.1	6 13	6 7	.....
Benicia, (San Francisco bay) ..	do.	14 10	1 0	4.5	5.1	3.7	6 26	5 59	.....
Ravenswood, (San Francisco bay) ..	do.	12 36	57	6.3	7.3	4.9	6 15	6 11	.....
Bodega	do.	11 17	1 54	3.6	4.7	2.7	6 19	5 59	.....
Humboldt bay	do.	12 2	1 11	4.4	5.5	3.5	6 19	6 0	.....
Port Orford	Oregon	11 26	1 6	5.1	6.8	3.7	6 19	6 7	39
Astoria	do.	12 42	1 13	6.1	7.4	4.6	6 3	6 28	33
Nee-ah harbor	Washington	12 33	1 28	5.6	7.4	4.8	6 20	6 6	.....
Port Townsend*	do.	3 49	1 3	4.6	5.5	4.0	6 34	5 52	.....
Stellacoom*	do.	4 46	1 6	9.2	11.1	7.2	6 3	6 25	28
Semi-ah-moo bay*	do.	4 50	1 2	5.7	6.6	4.8	6 11	6 19	26

* See remarks on page 92, and following.

NOTE.—The mean interval in column 3 has been increased by 12*h.* 26*m.* (half a mean lunar day) for some of the ports in Delaware river and Chesapeake bay, so as to show the succession of times from the mouth. Therefore 12*h.* 26*m.* ought to be subtracted from the establishments which are greater than that quantity before using them.

The foregoing Table I gives the means of determining, roughly, the time and height of high water at the several ports named. The hour of transit of the moon preceding the time of high water is to be taken from the Almanac, and, the mean establishment being added, the time of high water results. Thus:

Example I.—It is required to find the time of high water at New York on November 5, 1854. The American Almanac gives 0*h.* 0*m.* as the time of transit of the moon on that day. The mean interval for New York, from Table I, column 3, is 8*h.* 13*m.*, which, as the transit was at 0*h.*, is, roughly, the time of high water. The moon being full, the height is that of spring tides of column 6, viz: 5.4 feet. If the soundings on the chart are reduced to low-water spring tides, 5.4 feet are to be added to them to give the depth at high water. If the soundings are reduced to mean low water, the rise and fall of mean tides being 1.1 foot less than for springs, the rise or increase of depth will be half of this, or 0.6 of a foot less than 5.4 feet, which is 4.8 feet, or nearly four feet ten inches.

Example II.—Required the time of high water at Boston on January 23, 1851. From the American Almanac we find the time of the moon's southing or transit on that day 5*h.* 18*m.* a. m., and from Table I the mean interval at Boston dry dock is 11*h.* 27*m.*

We have then 5*h.* 18*m.*, time of transit.

To which add 11 27 mean interval from Table I.

16 45 time of high water, or 4*h.* 45*m.* p. m.

If the Greenwich Nautical Almanac is used, add 2*m.* to the time of transit of Greenwich for every hour of west longitude, and its proportional part for less than an hour. It will suffice to take the half hour which may be over any number of hours, as the correction for less than this would be less than one minute, and need not be taken into account. Thus, Boston is 4*h.* 44*m.* west of Greenwich. The correction to be applied to the time of transit of the moon is, for the four hours, eight minutes, and for the forty-four minutes, one minute. The time of transit on the date assumed in the preceding example is 17*h.* 9*m.* of the 22*d.* or 5*h.* 9*m.* a. m. of the 23*d.*, to which add nine minutes, the correction just found, gives 5*h.* 18*m.*, as before ascertained from the American Almanac.

In using the United States Nautical Almanac, in the astronomical part of which the transits of the moon are given for the meridian of Washington, the corrections required may, in this first approximation for the Atlantic coast, be neglected. To find the time of the next following low water, add, from Table I, the duration of ebb tide.

This gives 4*h.* 45*m.* p. m., time of high water.

6 13 duration of ebb from Table I.

10 58 p. m.

By subtracting the duration of flood tide we obtain the time of the preceding low water, 10*h.* 32*m.* a. m., recollecting that 4*h.* 45*m.* p. m. is the same as 16*h.* 45*m.* reckoned from midnight.

The height of this tide, corresponding to the transit of 5*h.*, will bring it nearly to a neap tide, and the rise and fall obtained from column 7, Table I, is 8.5 feet. The next following high water may be had by adding to the time of low water the duration of flood from Table I; thus:

10*h.* 58*m.* p. m., time of low water January 23.

6 13 duration of flood from Table I.

Sum 17 11 or 5*h.* 11*m.* on January 24.

Or, having found the time of high water, the time of the next following high water may be found by adding the duration of flood and ebb together, and their sum to the time of high water found; thus:

6*h.* 13*m.*, duration of ebb tide from Table I.

6 13 duration of flood.

Sum 12 26 duration of whole tide.

4 45 p. m., January 23, time of high water.

Sum 17 11 or 5*h.* 11*m.* a. m., January 24, time of the next succeeding high water.

Subtracting the same quantity will give the time of the preceding high water; thus:

4h. 43m. p. m., or 16h. 45m. from midnight, is the time of high water.

12 26 duration of flood and ebb tide.

4 19 a. m. of the 23d for the preceding high water.

The duration of the flood and the ebb being reckoned from the middle of one stand or slack water to the middle of the next, the time of beginning of stand of ebb or flood will be found by subtracting half the duration of stand or slack water given by column 10, Table I, from the time of high or low water, and the time of the end of the stand of ebb or flood by adding the same. A nearer approximation to the times and heights of high water may be obtained by the use of Tables II and III.

TABLE II.

Interval between the time of moon's transit and the time of high water for different hours of transit, and for several different ports

Time of moon's transit.	Boston, Mass.	New York, N. Y.	Philadelphia, Pa.	Old Point Comfort, Va.	Baltimore, Md.	Smithville, N. C.	Charleston, S. C.	Ft. Pulaski, Savannah, Ga.	Key West, Fla.	San Francisco, Cal.
<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>
0 0	11 38	8 20	1 31	8 55	6 47	7 26	7 38	7 39	9 33	12 5
0 30	11 33	8 18	1 28	8 49	6 42	7 21	7 33	7 25	9 26	11 59
1 0	11 28	8 15	1 25	8 44	6 37	7 16	7 27	7 19	9 19	11 53
1 30	11 24	8 10	1 21	8 40	6 31	7 13	7 21	7 15	9 13	11 47
2 0	11 20	8 6	1 18	8 35	6 26	7 9	7 16	7 11	9 6	11 41
2 30	11 16	8 0	1 14	8 32	6 21	7 6	7 12	7 8	9 1	11 36
3 0	11 13	7 55	1 11	8 27	6 17	7 4	7 8	7 6	8 57	11 33
3 30	11 10	7 52	1 8	8 22	6 13	7 3	7 5	7 5	8 53	11 33
4 0	11 7	7 52	1 6	8 20	6 11	7 2	7 2	7 4	8 53	11 38
4 30	11 6	7 52	1 3	8 21	6 10	7 3	7 2	7 3	8 56	11 46
5 0	11 6	7 53	1 0	8 23	6 10	7 4	7 3	7 4	9 2	11 55
5 30	11 9	7 56	0 59	8 26	6 13	7 6	7 7	7 6	9 10	12 3
6 0	11 13	7 59	0 59	8 32	6 19	7 9	7 12	7 8	9 22	12 11
6 30	11 19	8 5	1 1	8 39	6 25	7 13	7 19	7 12	9 33	12 16
7 0	11 25	8 11	1 7	8 48	6 32	7 17	7 24	7 16	9 40	12 23
7 30	11 32	8 17	1 15	8 58	6 39	7 23	7 32	7 22	10 0	12 29
8 0	11 38	8 23	1 23	9 4	6 44	7 28	7 38	7 28	10 6	12 34
8 30	11 43	8 27	1 29	9 8	6 49	7 33	7 45	7 34	10 7	12 37
9 0	11 47	8 32	1 34	9 10	6 52	7 37	7 48	7 39	10 6	12 36
9 30	11 48	8 34	1 39	9 12	6 54	7 39	7 50	7 42	10 3	12 34
10 0	11 49	8 35	1 42	9 10	6 53	7 40	7 50	7 43	9 59	12 30
10 30	11 48	8 34	1 43	9 8	6 52	7 40	7 47	7 41	9 56	12 24
11 0	11 47	8 31	1 41	9 4	6 50	7 36	7 44	7 37	9 48	12 17
11 30	11 43	8 25	1 37	9 2	6 48	7 30	7 41	7 34	9 40	12 9

TABLE III.

Showing the rise and fall of tides, and corrections to be applied to determine the depth at high water of soundings on charts referred to mean low water, and to low water spring tides.

Time of moon's transit.	Boston, Mass.			New York, N. Y.			Philadelphia, Pa.			Old Point Comfort, Va.			Baltimore, Md.			Time of moon's transit.
	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	
Hour.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Hour.
0	11.2	10.6	11.3	4.9	4.5	4.9	6.3	6.2	6.3	2.9	2.6	2.9	1.5	1.4	1.6	0
1	11.3	10.6	11.3	4.9	4.5	4.9	6.4	6.4	6.5	3.0	2.7	3.0	1.5	1.4	1.6	1
2	11.2	10.5	11.2	4.7	4.4	4.8	6.6	6.5	6.6	2.9	2.7	2.9	1.5	1.3	1.5	2
3	10.6	10.3	10.9	4.3	4.2	4.6	6.6	6.5	6.6	2.6	2.6	2.8	1.4	1.3	1.5	3
4	10.0	10.0	10.7	3.8	4.0	4.4	6.4	6.4	6.5	2.3	2.4	2.7	1.3	1.2	1.4	4
5	9.2	9.7	10.4	3.5	3.8	4.2	6.1	6.2	6.3	2.1	2.3	2.6	1.1	1.1	1.3	5
6	8.8	9.4	10.1	3.3	3.7	4.1	5.7	5.9	6.0	2.0	2.2	2.5	0.9	1.1	1.3	6
7	8.6	9.3	10.0	3.3	3.7	4.1	5.4	5.6	5.7	2.0	2.3	2.5	0.9	1.1	1.3	7
8	8.9	9.5	10.2	3.6	3.8	4.2	5.2	5.3	5.4	2.2	2.4	2.6	1.0	1.2	1.4	8
9	9.4	9.7	10.4	4.0	4.0	4.4	5.4	5.4	5.5	2.5	2.5	2.8	1.1	1.3	1.5	9
10	10.1	10.0	10.7	4.5	4.3	4.7	5.7	5.7	5.8	2.8	2.7	2.9	1.3	1.4	1.6	10
11	10.7	10.3	11.0	5.8	4.5	4.9	6.0	6.0	6.1	3.0	2.8	3.0	1.4	1.4	1.6	11

TABLE III—Continued.

Time of moon's transit.	Smithville, N. C.			Charleston, S. C.			Fort Pulaski, Savannah entrance.			Key West, Fla.			San Francisco, Cal.			Time of moon's transit.
	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	
Hour.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Hour.
0	5.2	4.8	5.1	6.0	5.5	6.0	7.8	7.4	7.8	1.5	1.4	1.5	4.5	4.0	4.4	0
1	5.1	4.8	5.1	5.9	5.5	5.9	7.9	7.4	7.9	1.5	1.4	1.5	3.9	3.7	4.1	1
2	5.0	4.7	5.0	5.7	5.4	5.8	7.6	7.3	7.7	1.5	1.4	1.5	3.7	3.6	4.1	2
3	4.6	4.5	4.8	5.3	5.2	5.6	7.1	7.0	7.5	1.4	1.3	1.4	3.5	3.5	4.0	3
4	4.3	4.4	4.7	4.7	4.9	5.4	6.5	6.7	7.2	1.2	1.2	1.3	3.1	3.3	3.8	4
5	4.0	4.3	4.6	4.4	4.8	5.2	6.1	6.5	7.0	1.0	1.1	1.2	2.8	3.1	3.6	5
6	3.8	4.2	4.5	4.2	4.6	5.1	5.8	6.4	6.8	0.9	1.0	1.1	2.7	3.1	3.6	6
7	3.8	4.1	4.4	4.3	4.7	5.1	6.0	6.5	6.9	0.9	1.1	1.2	3.0	3.3	3.7	7
8	4.0	4.2	4.5	4.5	4.8	5.3	6.4	6.7	7.1	1.0	1.2	1.3	3.4	3.5	3.9	8
9	4.3	4.3	4.6	5.0	5.0	5.5	6.9	6.9	7.4	1.2	1.3	1.4	3.8	3.6	4.1	9
10	4.7	4.6	4.9	5.5	5.3	5.8	7.4	7.0	7.6	1.4	1.4	1.5	4.0	3.8	4.2	10
11	5.0	4.7	5.0	5.9	5.5	5.9	7.8	7.2	7.8	1.5	1.4	1.5	4.2	3.8	4.3	11

In these the variations in the interval between the moon's transit and high water are shown for some of the principal ports contained in Table I. These variations of intervals depend upon the age of the moon, and, as they go through their values in half a lunar month, are known as the half-monthly inequality of interval. The table extends from the 0^h. of transit, midnight of the calendar day, or full of the moon, to 11½ hours. The numbers for change of the moon correspond to those of 0^h., and for 13 hours (or 1^h. p. m. of the calendar day) to 1 hour, and so on up to 23 hours. The ports for which the numbers are given are designated by the heading of the column.

The mean interval, it will be seen, does not occur at full and change, but nearly two days afterwards, on the Atlantic coast. At Key West it occurs more nearly at full and change, and at San Francisco still more nearly.

The same remark applies to the heights; spring tides occur about two days after the full and change of

the moon, and neaps two days after the first and last quarters. The use of this table of nearer approximation is quite as simple as that of Table I.

Rule to find the time of high water.—Look in the Almanac for the time of the moon's transit (or southing) for the date required. In the table corresponding to that time will be found the number to be added to the time of transit.

Example III.—Required, the time of high water at New York October 1, 1856. Using the United States Nautical Almanac, we find the time of the moon's transit 1*h.* 24*m.*, astronomical reckoning, or 1*h.* 24*m.* p. m. calendar time. From Table II we have, under the heading of New York, for 1*h.* 30*m.* (the nearest number to 1*h.* 24*m.* in the table) 8*h.* 10*m.*

Thus, to 1*h.* 24*m.*, time of moon's transit,

Add 8 10 interval found in Table III.

—
The sum 9 34 p. m. is the time of high water on the 1st of October, 1856.

If the sum of these numbers had exceeded twelve, the tide would have belonged to October 2, and we must have gone back to the transit of the day before and computed with it to obtain the tide of October 1.

Rule to find the height of high water.—Enter Table III, column 1, with the time of moon's transit. In the column headed with the name of the place, and marked A, will be found the rise and fall corresponding to the time of transit; in column B the number to be added to soundings on the chart, where the soundings are given for mean low water; in column C the number to be added to charts of which the soundings are given for low water spring tides.

In the foregoing example, (III,) the time of transit being between 1 and 2 hours, we find from Table III the rise and fall of tides on the 1st of October, 1856, between 4.9 and 4.7; the number to be added to sounding given for mean low water 4.5 feet, (column B,) and for low water spring tides (column C) 4.9 feet.

Having found the time of high water, that of low water may be obtained, nearly, by adding the duration of ebb from column 9, Table I. The time of the next preceding low water may be found by subtracting the duration of flood from column 8, Table I. The time of the next following high water may be found by adding the duration of both flood and ebb, and of the next preceding high water by subtracting the same duration of the whole tide.

Example IV.—To find the next high water following that of Example III.

The duration of flood, column 8, Table I, for New York, is 6*h.* 0*m.*; and of ebb, from column 9, is 6*h.* 25*m.*; the sum is 12*h.* 25*m.*

To 9*h.* 34*m.* p. m., October 1, time of high water found,

Add 12 25 duration of flood and ebb.

—
Sum 21 59 or 9*h.* 59*m.* a. m. of October 2, the time of the next high water.

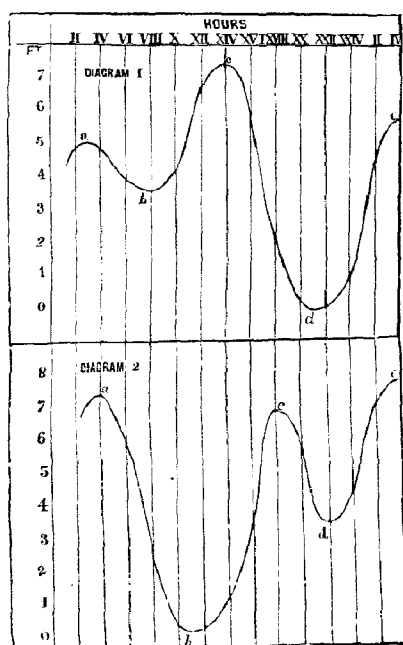
TIDES OF THE PACIFIC COAST AND OF PART OF THE COAST OF FLORIDA.

On the Pacific coast there are, as a general rule, one large and one small tide during the day, the height of the two successive high waters occurring one a. m. the other p. m. of the same twenty-four hours, and the intervals from the next preceding transit of the moon are very different. The inequalities depend upon the moon's declination; they disappear near the time of the moon's declination being nothing, and are greatest about the time of its being greatest. The inequalities for low water are not the same as for high, though they disappear and have the greatest value at nearly the same times. The tides of the southern part of Florida and of the western coast of that peninsula, as far as St. Mark's, are of the same character.

In Puget's sound the inequalities for the interval of high water and for the height of low water follow this rule; but those for the interval of low water and height of high water disappear about one day before the moon's declination is greatest, and are greatest about four or five days before the greatest declination.

When the moon's declination is north, the highest of the two tides of the twenty-four hours occurs at San Francisco about eleven and a half hours after the moon's southing, (transit;) and when the declination is south, the lowest of the two high tides occurs about that interval.

The lowest of the two low waters of the day is one which follows next the highest high water. The nature of these tides will probably appear more plainly from the annexed diagrams. In them the height of



the tide is set off at the side on a scale of feet, and the hours of the day are at the top. At 12 noon, for example, the tide-gauge marked 6.7 feet. Joining all the heights observed in the twenty-four hours, we have a curve like that marked in the figure. The two high waters are *a* and *c*; the two low waters *b* and *d*. If *a* is the high water which occurs about twelve hours after the transit of the moon, when the declination is south, the ebb *a b* is quite small, and the high water, *a*, is much lower than the next high water, *c*. If the moon's declination is north, it is the large high water, *a*, of the second diagram which occurs next after the transit, and about twelve hours from it. At Key West the contrary obtains, diagram 1 applying when the moon's declination is north, and diagram 2 when south. Tables IV and V give the number to be added to the time of moon's transit to find the time of high water almost as readily as in the former case. They are of double entry, the time of transit being, as before, placed in the first column. The number of days from the day at which the moon had the greatest declination is arranged at the top of the table. Entering the first column with the time of transit, and following the line horizontally until we come under the column containing the days from the greatest declination, we find the number to be added to the time of the transit to give the time of high water. If the moon's declination is south, Table IV is to be used; if north, Table V.

Tables IV to IX, inclusive, have been recomputed, using more complete data for the inequalities above referred to, and to those for San Francisco similar tables have been added for San Diego, Astoria, Port Townshend, and Key West, Fla. For the other places on the Western Coast given in Table I the following rules will give sufficiently close approximations.

To obtain the times of high or low water for San Pedro, Cuyler's harbor, and San Luis Obispo, compute first the time for San Diego by Tables IV, V, or VIII; then add to the time thus obtained 30 minutes to obtain the time for San Luis Obispo, and subtract 13 minutes for Cuyler's harbor. At San Pedro the time of high or low water is sensibly the same as at San Diego.

For Monterey, South Farallon, Mare Island, Benicia, Ravenswood, and Bodega, compute first the time for San Francisco; then subtract from the time thus obtained 1*h.* 44*m.* for Monterey, 1*h.* 29*m.* for the South Farallon, and 49*m.* for Bodega, and add 34*m.* for Mare Island, 1*h.* 4*m.* for Benicia, and 30*m.* for Ravenswood. For Humboldt bay, Port Orford, and Neeah harbor, compute first the time for Astoria; then subtract from it 40*m.* for Humboldt bay, 1*h.* 16*m.* for Port Orford, and 9*m.* for Neeah harbor.

For Steilacoom and Semiahmoo bay, compute first the time for Port Townshend, and add to it 57*m.* for Steilacoom and 1*h.* for Semiahmoo. The approximation will be only a rough one for Steilacoom.

For the heights, Tables VI, VII, and IX for San Diego can be used without change for San Pedro, Cuyler's harbor, and San Luis Obispo. These tables for San Francisco are also applicable to Monterey, South Farallon, and Bodega. For Mare Island add 1.2 foot, for Benicia 0.9 foot, and for Ravenswood 2.7 feet, to the quantities for San Francisco.

For Humboldt bay, Port Orford, and Neeah harbor, the tables for Astoria may be used, subtracting 1.7 foot for Humboldt bay, and 1.0 foot for Port Orford. For Neeah harbor the tables will give approximate results without change.

For Semiahmoo bay, add one foot to the quantities in the tables for Port Townshend. For Steilacoom, a rough approximate may be obtained by adding 4.6 feet to them.

For the coast of Florida, compute the times of high or low water for Key West, and subtract 1*h.* 7*m.* for Indian key, and add 26*m.* for Tortugas, 3*h.* 39*m.* for Charlotte harbor, 1*h.* 51*m.* for Egmont key, 3*h.* 45*m.* for Cedar keys, and 4*h.* 8*m.* for St. Mark's. For the heights, add half a foot for Indian key, and use the tables without change for Tortugas and Egmont key. For Cedar keys and St. Mark's the results could not be obtained with much accuracy in this way; special tables will be prepared for those places.

TABLE IV.—KEY WEST.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—							0	After—						
	7	6	5	4	3	2	1		1	2	3	4	5	6	7
<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>
0 0	9 40	9 30	9 18	9 07	9 01	8 49	8 44	8 40	8 40	8 46	8 54	9 06	9 16	9 27	9 37
0 30	9 33	9 23	9 11	9 00	8 54	8 42	8 37	8 33	8 33	8 39	8 47	8 59	9 09	9 20	9 30
1 0	9 26	9 16	9 04	8 53	8 47	8 35	8 30	8 26	8 26	8 32	8 40	8 52	9 02	9 13	9 23
1 30	9 20	9 10	8 58	8 47	8 41	8 29	8 24	8 20	8 20	8 26	8 34	8 46	8 56	9 07	9 17
2 0	9 13	9 03	8 51	8 40	8 34	8 22	8 17	8 13	8 13	8 19	8 27	8 39	8 49	9 00	9 10
2 30	9 08	8 58	8 46	8 35	8 29	8 17	8 12	8 08	8 08	8 14	8 22	8 34	8 44	8 55	9 05
3 0	9 04	8 54	8 42	8 31	8 25	8 13	8 08	8 04	8 04	8 10	8 18	8 30	8 40	8 51	9 01
3 30	9 00	8 50	8 38	8 27	8 21	8 09	8 04	8 00	8 00	8 06	8 14	8 26	8 36	8 47	8 57
4 0	9 00	8 50	8 38	8 27	8 21	8 09	8 04	8 00	8 00	8 06	8 14	8 26	8 36	8 47	8 57
4 30	9 03	8 53	8 41	8 30	8 24	8 12	8 07	8 03	8 03	8 09	8 17	8 29	8 39	8 50	9 00
5 0	9 09	8 59	8 47	8 36	8 30	8 18	8 13	8 09	8 09	9 15	8 23	8 35	8 45	8 56	9 06
5 30	9 17	9 07	8 55	8 44	8 38	8 26	8 21	8 17	8 17	8 23	8 31	8 43	8 53	9 04	9 14
6 0	9 29	9 19	9 07	8 56	8 50	8 38	8 33	8 29	8 29	8 35	8 43	8 55	9 05	9 16	9 26
6 30	9 40	9 30	9 18	9 07	9 01	8 49	8 44	8 40	8 40	8 46	8 54	9 06	9 16	9 27	9 37
7 0	9 56	9 46	9 34	9 23	9 17	9 05	9 00	8 56	8 56	9 02	9 10	9 22	9 32	9 43	9 53
7 30	10 07	9 57	9 45	9 34	9 28	9 16	9 11	9 07	9 07	9 13	9 21	9 33	9 43	9 54	10 04
8 0	10 13	10 03	9 51	9 40	9 34	9 22	9 17	9 13	9 13	9 19	9 27	9 39	9 49	10 00	10 00
8 30	10 14	10 04	9 52	9 41	9 35	9 23	9 18	9 14	9 14	9 20	9 28	9 40	9 50	10 01	10 11
9 0	10 13	10 03	9 51	9 40	9 34	9 22	9 17	9 13	9 13	9 19	9 27	9 39	9 49	10 00	10 10
9 30	10 10	10 00	9 48	9 37	9 31	9 19	9 14	9 10	9 10	9 16	9 24	9 36	9 46	9 57	10 07
10 0	10 06	9 56	9 44	9 33	9 27	9 15	9 10	9 06	9 06	9 12	9 20	9 32	9 42	9 53	10 03
10 30	10 03	9 53	9 41	9 30	9 24	9 12	9 07	9 03	9 03	9 09	9 17	9 29	9 39	9 50	10 00
11 0	9 55	9 45	9 33	9 22	9 16	9 04	8 59	8 55	8 55	9 01	9 09	9 21	9 31	9 42	9 52
11 30	9 47	9 37	9 25	9 14	9 08	8 56	8 51	8 47	8 47	8 53	9 01	9 13	9 23	9 34	9 44

TABLE V.—KEY WEST.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—							0	After—						
	7	6	5	4	3	2	1		1	2	3	4	5	6	7
<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>
0 0	9 29	9 36	9 43	9 53	10 06	10 16	10 22	10 22	10 22	10 18	10 06	9 56	9 43	9 34	9 27
0 30	9 22	9 29	9 36	9 46	9 59	10 09	10 15	10 15	10 15	10 11	9 59	9 49	9 36	9 27	9 20
1 0	9 15	9 22	9 29	9 39	9 52	10 02	10 08	10 08	10 08	10 04	9 52	9 42	9 29	9 20	9 13
1 30	9 09	9 16	9 23	9 33	9 46	9 56	10 02	10 02	10 02	9 58	9 46	9 36	9 23	9 14	9 07
2 0	9 02	9 09	9 16	9 26	9 39	9 49	9 55	9 55	9 55	9 51	9 39	9 29	9 16	9 07	9 00
2 30	8 57	9 04	9 11	9 21	9 34	9 44	9 50	9 50	9 50	9 46	9 34	9 24	9 11	9 02	8 55
3 0	8 53	9 00	9 07	9 17	9 30	9 40	9 46	9 46	9 46	9 42	9 30	9 20	9 07	8 58	8 51
3 30	8 49	8 56	9 03	9 13	9 26	9 36	9 42	9 42	9 42	9 38	9 26	9 16	9 03	8 54	8 47
4 0	8 49	8 56	9 03	9 13	9 26	9 36	9 42	9 42	9 42	9 38	9 26	9 16	9 03	8 54	8 47
4 30	8 52	8 59	9 06	9 16	9 29	9 39	9 45	9 45	9 45	9 41	9 30	9 20	9 06	8 57	8 50
5 0	8 58	9 05	9 12	9 22	9 35	9 45	9 51	9 51	9 51	9 47	9 35	9 25	9 12	9 03	8 56
5 30	9 06	9 13	9 20	9 30	9 43	9 53	9 59	9 59	9 59	9 55	9 43	9 33	9 20	9 11	9 04
6 0	9 18	9 25	9 32	9 42	9 55	10 05	10 11	10 11	10 11	10 07	9 55	9 45	9 32	9 23	9 16
6 30	9 29	9 36	9 43	9 53	10 06	10 16	10 22	10 22	10 22	10 18	10 06	9 56	9 43	9 34	9 27
7 0	9 45	9 52	9 59	10 09	10 22	10 32	10 38	10 38	10 38	10 34	10 22	10 12	9 59	9 50	9 43
7 30	9 56	10 03	10 10	10 20	10 33	10 43	10 49	10 49	10 49	10 45	10 33	10 23	10 10	10 01	9 54
8 0	10 02	10 09	10 16	10 26	10 39	10 49	10 55	10 55	10 55	10 51	10 39	10 29	10 16	10 07	10 00
8 30	10 03	10 10	10 17	10 27	10 40	10 50	10 56	10 56	10 56	10 52	10 40	10 30	10 17	10 08	10 01
9 0	10 02	10 09	10 16	10 26	10 39	10 49	10 55	10 55	10 55	10 51	10 39	10 29	10 16	10 07	10 00
9 30	9 59	10 06	10 13	10 23	10 36	10 46	10 52	10 52	10 52	10 48	10 36	10 26	10 13	10 04	9 57
10 0	9 55	10 02	10 09	10 19	10 32	10 42	10 48	10 48	10 48	10 44	10 32	10 22	10 09	10 00	9 53
10 30	9 52	9 59	10 06	10 16	10 29	10 39	10 45	10 45	10 45	10 41	10 29	10 19	10 06	9 57	9 50
11 0	9 44	9 51	9 58	10 08	10 21	10 31	10 37	10 37	10 37	10 33	10 21	10 11	9 58	9 49	9 42
11 30	9 36	9 43	9 50	10 00	10 13	10 23	10 29	10 29	10 29	10 25	10 13	10 03	9 50	9 41	9 34

REPORT OF THE SUPERINTENDENT OF

TABLE IV.—SAN DIEGO.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.															
	Before—								After—							
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>
0 0	9 25	9 40	9 52	10 3	10 12	10 20	10 25	10 29	10 29	10 25	10 19	10 10	10 0	9 47	9 30	
0 30	9 15	9 30	9 42	9 53	10 2	10 10	10 15	10 19	10 19	10 15	10 9	10 0	9 50	9 27	9 20	
1 0	9 8	9 23	9 35	9 46	9 55	10 3	10 8	10 12	10 12	10 8	10 2	9 53	9 43	9 30	9 13	
1 30	9 1	9 16	9 28	9 39	9 48	9 56	10 1	10 5	10 5	10 1	9 55	9 46	9 36	9 23	9 6	
2 0	8 54	9 9	9 21	9 32	9 41	9 49	9 54	9 58	9 58	9 54	9 48	9 39	9 29	9 16	8 59	
2 30	8 49	9 4	9 16	9 27	9 36	9 44	9 49	9 53	9 53	9 49	9 43	9 34	9 24	9 11	8 54	
3 0	8 48	9 3	9 15	9 26	9 35	9 43	9 48	9 52	9 52	9 48	9 42	9 33	9 23	9 10	8 53	
3 30	8 48	9 3	9 15	9 26	9 35	9 43	9 48	9 52	9 52	9 48	9 42	9 33	9 23	9 10	8 53	
4 0	8 52	9 7	9 19	9 30	9 39	9 47	9 52	9 56	9 56	9 52	9 46	9 37	9 27	9 14	8 57	
4 30	8 56	9 11	9 23	9 34	9 43	9 51	9 56	10 0	10 0	9 56	9 50	9 41	9 31	9 18	9 1	
5 0	9 15	9 30	9 42	9 53	10 2	10 10	10 15	10 19	10 19	10 15	10 9	10 0	9 50	9 37	9 20	
5 30	9 37	9 52	10 4	10 15	10 24	10 32	10 37	10 41	10 41	10 37	10 31	10 22	10 12	9 59	9 42	
6 0	9 55	10 10	10 22	10 33	10 42	10 50	10 55	10 59	10 59	10 55	10 49	10 40	10 30	10 17	10 0	
6 30	10 12	10 27	10 39	10 50	10 59	11 7	11 12	11 16	11 16	11 12	11 6	10 57	10 47	10 34	10 17	
7 0	10 18	10 33	10 45	10 56	11 5	11 13	11 18	11 22	11 22	11 18	11 12	11 3	10 53	10 40	10 23	
7 30	10 39	10 35	10 47	10 58	11 7	11 15	11 20	11 24	11 24	11 20	11 14	11 5	10 55	10 42	10 25	
8 0	10 22	10 37	10 49	11 0	11 9	11 17	11 22	11 26	11 26	11 22	11 16	11 7	10 57	10 44	10 27	
8 30	10 24	10 39	10 51	11 2	11 11	11 19	11 24	11 28	11 28	11 24	11 18	11 9	10 59	10 46	10 29	
9 0	10 18	10 33	10 45	10 56	11 5	11 13	11 18	11 22	11 22	11 18	11 12	11 3	10 53	10 40	10 23	
9 30	10 10	10 25	10 37	10 48	10 57	11 5	11 10	11 14	11 14	11 10	11 4	10 55	10 45	10 32	19 15	
10 0	10 0	10 15	10 27	10 38	10 47	10 55	11 0	11 4	11 4	11 0	10 54	10 45	10 35	10 22	10 5	
10 30	9 53	10 8	10 20	10 31	10 40	10 48	10 53	10 57	10 57	10 53	10 47	10 38	10 28	10 15	9 58	
11 0	9 45	10 0	10 12	10 23	10 32	10 40	10 45	10 49	10 49	10 45	10 39	10 30	10 20	10 7	9 50	
11 30	9 36	9 51	10 3	10 14	10 23	10 31	10 36	10 40	10 40	10 36	10 30	10 21	10 11	9 58	9 41	

TABLE V.—SAN DIEGO.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.															
	Before—								After—							
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>
0 0	9 30	9 16	9 4	8 53	8 44	8 36	8 31	8 27	8 27	8 31	8 37	8 46	8 56	9 9	9 26	
0 30	9 21	9 6	8 54	8 43	8 34	8 26	8 21	8 17	8 17	8 21	8 27	8 36	8 46	8 59	9 16	
1 0	9 14	8 59	8 47	8 36	8 27	8 19	8 14	8 10	8 10	8 14	8 20	8 29	8 39	8 52	9 9	
1 30	9 7	8 52	8 40	8 29	8 20	8 12	8 7	8 3	8 3	8 7	8 13	8 22	8 32	8 45	9 2	
2 0	9 0	8 45	8 33	8 22	8 13	8 5	8 0	7 56	7 56	8 0	8 6	8 15	8 25	8 38	8 55	
2 30	8 55	8 40	8 28	8 17	8 8	8 0	7 55	7 51	7 51	7 55	8 1	8 10	8 20	8 33	8 50	
3 0	8 54	8 39	8 27	8 1	8 7	7 59	7 54	7 50	7 50	7 54	8 0	8 9	8 19	8 32	8 49	
3 30	8 54	8 39	8 27	8 16	8 7	7 59	7 54	7 50	7 50	7 54	8 0	8 9	8 19	8 32	8 49	
4 0	8 58	8 43	8 31	8 20	8 11	8 3	7 58	7 54	7 54	7 58	8 4	8 13	8 23	8 36	8 53	
4 30	9 2	8 47	8 35	8 24	8 15	8 7	8 2	7 58	7 58	8 2	8 8	8 17	8 27	8 40	8 57	
5 0	9 21	9 6	8 54	8 43	8 34	8 26	8 21	8 17	8 17	8 21	8 27	8 36	8 46	8 59	9 16	
5 30	9 43	9 28	9 16	9 5	8 56	8 48	8 43	8 39	8 39	8 43	8 49	8 58	9 8	9 21	9 38	
6 0	10 1	9 46	9 34	9 23	9 14	9 6	9 1	8 57	8 57	9 1	9 7	9 16	9 26	9 39	9 56	
6 30	10 12	10 3	9 51	9 40	9 31	9 23	9 18	9 14	9 14	9 18	9 24	9 33	9 43	9 56	10 13	
7 0	10 24	10 9	9 57	9 46	9 37	9 29	9 24	9 20	9 20	9 24	9 30	9 39	9 49	10 2	10 19	
7 30	10 26	10 11	9 59	9 48	9 39	9 31	9 26	9 22	9 22	9 26	9 32	9 41	9 51	10 4	10 21	
8 0	10 28	10 13	10 1	9 50	9 41	9 33	9 28	9 24	9 24	9 28	9 34	9 43	9 53	10 6	10 23	
8 30	10 30	10 15	10 3	9 52	9 43	9 35	9 30	9 26	9 26	9 30	9 36	9 45	9 55	10 8	10 25	
9 0	10 24	10 9	9 57	9 46	9 37	9 29	9 24	9 20	9 20	9 24	9 30	9 39	9 49	10 2	10 19	
9 30	10 16	10 1	9 49	9 38	9 29	9 21	9 16	9 12	9 12	9 16	9 22	9 31	9 41	9 54	10 11	
10 0	10 6	9 51	9 39	9 28	9 19	9 11	9 6	9 2	9 2	9 6	9 12	9 21	9 31	9 44	10 1	
10 30	9 59	9 44	9 32	9 21	9 12	9 4	8 59	8 55	8 55	8 59	9 5	9 14	9 24	9 37	9 54	
11 0	9 51	9 36	9 24	9 13	9 4	8 56	8 51	8 47	8 47	8 51	8 57	9 6	9 16	9 29	9 46	
11 30	9 42	9 27	9 15	9 4	8 55	8 47	8 42	8 38	8 38	8 42	8 48	8 57	9 7	9 20	9 37	

TABLE IV.—SAN FRANCISCO.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.															
	Before—								After—							
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>
0 0	11 43	11 59	12 15	12 33	12 50	13 03	13 17	13 29	13 19	13 14	13 07	12 57	12 45	12 32	12 18	
0 30	11 37	11 53	12 09	12 27	12 44	12 57	13 11	13 14	13 13	13 08	13 01	12 51	12 39	12 26	12 12	
1 0	11 31	11 47	12 03	12 21	12 38	12 51	13 05	13 08	13 07	13 02	12 55	12 45	12 33	12 20	12 06	
1 30	11 25	11 41	11 57	12 15	12 32	12 45	12 59	13 02	13 01	12 56	12 49	12 39	12 27	12 14	12 00	
2 0	11 19	11 35	11 51	12 09	12 26	12 39	12 53	12 56	12 55	12 50	12 43	12 33	12 21	12 08	11 54	
2 30	11 14	11 30	11 46	12 04	12 21	12 34	12 48	12 51	12 50	12 45	12 38	12 28	12 16	12 03	11 49	
3 0	11 11	11 27	11 43	12 01	12 18	12 31	12 45	12 48	12 47	12 42	12 35	12 25	12 13	12 00	11 46	
3 30	11 11	11 27	11 43	12 01	12 18	12 31	12 45	12 48	12 47	12 42	12 35	12 25	12 13	12 00	11 46	
4 0	11 16	11 32	11 48	12 06	12 23	12 36	12 50	12 53	12 52	12 47	12 40	12 30	12 18	12 05	11 51	
4 30	11 24	11 40	11 56	12 14	12 31	12 44	12 58	13 01	13 00	12 55	12 48	12 38	12 26	12 13	11 59	
5 0	11 33	11 49	12 05	12 23	12 40	12 53	13 07	13 10	13 09	13 04	12 57	12 47	12 35	12 22	12 08	
5 30	11 41	11 57	12 13	12 31	12 48	13 01	13 15	13 18	13 17	13 12	13 05	12 55	12 43	12 30	12 16	
6 0	11 49	12 05	12 21	12 39	12 56	13 09	13 23	13 26	13 25	13 20	13 13	13 03	12 51	12 38	12 24	
6 30	11 54	12 10	12 26	12 44	13 01	13 14	13 28	13 31	13 30	13 25	13 18	13 08	12 56	12 43	12 29	
7 0	12 01	12 17	12 33	12 51	13 08	13 21	13 35	13 38	13 37	13 32	13 25	13 15	13 03	12 50	12 36	
7 30	12 07	12 23	12 39	12 57	13 14	13 27	13 41	13 44	13 43	13 38	13 31	13 21	13 09	12 56	12 42	
8 0	12 12	12 28	12 44	13 02	13 19	13 32	13 46	13 49	13 48	13 43	13 36	13 26	13 14	13 01	12 47	
8 30	12 15	12 31	12 47	13 05	13 22	13 35	13 49	13 52	13 51	13 46	13 39	13 29	13 17	13 04	12 50	
9 0	12 14	12 30	12 46	13 04	13 21	13 34	13 48	13 57	13 50	13 45	13 38	13 28	13 16	13 03	12 49	
9 30	12 12	12 28	12 44	13 02	13 19	13 32	13 46	13 49	13 48	13 43	13 36	13 26	13 14	13 01	12 47	
10 0	12 08	12 24	12 40	12 58	13 15	13 28	13 42	13 45	13 44	13 39	13 32	13 22	13 10	12 57	12 43	
10 30	12 02	12 18	12 34	12 52	13 09	13 22	13 36	13 39	13 38	13 33	13 26	13 16	13 04	12 51	12 37	
11 0	11 55	12 11	12 27	12 45	13 02	13 15	13 29	13 32	13 31	13 26	13 19	13 09	12 57	12 44	12 30	
11 30	11 47	12 03	12 19	12 37	12 54	13 07	13 21	13 24	13 23	13 18	13 11	13 01	12 49	12 36	12 22	

TABLE V.—SAN FRANCISCO.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.															
	Before—								After—							
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>
0 0	12 27	12 11	11 55	11 37	11 20	11 07	10 53	10 50	10 51	10 56	11 03	11 13	11 25	11 38	11 52	
0 30	12 21	12 05	11 49	11 31	11 14	11 01	10 47	10 44	10 45	10 50	10 57	11 07	11 19	11 32	11 46	
1 0	12 15	11 59	11 43	11 25	11 08	10 55	10 41	10 38	10 39	10 44	10 51	11 01	11 13	11 26	11 40	
1 30	12 09	11 53	11 37	11 19	11 02	10 49	10 35	10 32	10 33	10 38	10 45	10 55	11 07	11 20	11 34	
2 0	12 03	11 47	11 31	11 13	10 56	10 43	10 29	10 26	10 27	10 32	10 39	10 49	11 01	11 14	11 28	
2 30	11 58	11 42	11 26	11 08	10 51	10 38	10 24	10 21	10 22	10 27	10 34	10 44	10 56	11 09	11 23	
3 0	11 53	11 39	11 23	11 05	10 48	10 35	10 21	10 18	10 19	10 24	10 31	10 41	10 53	11 06	11 20	
3 30	11 55	11 39	11 23	11 05	10 48	10 35	10 21	10 18	10 19	10 24	10 31	10 41	10 53	11 06	11 20	
4 0	12 00	11 44	11 28	11 10	10 53	10 40	10 26	10 23	10 24	10 29	10 36	10 46	10 58	11 11	11 25	
4 30	12 08	11 52	11 36	11 18	11 01	10 48	10 34	10 31	10 32	10 37	10 44	10 54	11 06	11 19	11 33	
5 0	12 17	12 01	11 45	11 27	11 10	10 57	10 43	10 40	10 41	10 46	10 53	11 03	11 15	11 28	11 42	
5 30	12 25	12 09	11 53	11 35	11 18	11 05	10 51	10 48	10 49	10 54	11 01	11 11	11 23	11 36	11 50	
6 0	12 33	12 17	12 01	11 43	11 26	11 13	10 59	10 56	10 57	11 02	11 09	11 19	11 31	11 44	11 58	
6 30	12 38	12 22	12 06	11 48	11 31	11 18	11 04	11 01	11 02	11 07	11 14	11 24	11 36	11 49	12 03	
7 0	12 45	12 29	12 13	11 55	11 38	11 25	11 11	11 08	11 09	11 14	11 21	11 31	11 43	11 56	12 10	
7 30	12 51	12 35	12 19	12 01	11 44	11 31	11 17	11 14	11 15	11 20	11 27	11 37	11 49	12 02	12 16	
8 0	12 56	12 40	12 24	12 06	11 49	11 36	11 22	11 19	11 20	11 25	11 32	11 42	11 54	12 07	12 21	
8 30	12 59	12 43	12 27	12 09	11 52	11 39	11 25	11 22	11 23	11 28	11 35	11 45	11 57	12 10	12 24	
9 0	12 58	12 42	12 26	12 08	11 51	11 38	11 24	11 21	11 22	11 27	11 34	11 44	11 56	12 09	12 23	
9 30	12 56	12 40	12 24	12 06	11 49	11 36	11 22	11 19	11 20	11 25	11 32	11 42	11 54	12 07	12 21	
10 0	12 52	12 36	12 20	12 02	11 45	11 32	11 18	11 15	11 16	11 21	11 28	11 38	11 50	12 03	12 17	
10 30	12 46	12 30	12 14	11 56	11 39	11 26	11 12	11 09	11 10	11 15	11 22	11 32	11 44	11 57	12 11	
11 0	12 39	12 23	12 07	11 49	11 32	11 19	11 05	11 02	11 03	11 08	11 15	11 25	11 37	11 50	12 04	
11 30	12 31	12 15	11 59	11 41	11 24	11 11	10 57	10 54	10 55	11 00	11 07	11 17	11 29	11 42	11 56	

REPORT OF THE SUPERINTENDENT OF

TABLE IV.—ASTORIA.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—							0	After.						
	7	6	5	4	3	2	1		1	2	3	4	5	6	7
<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>
0 0	12 42	12 55	13 5	13 18	13 28	13 38	13 41	13 45	13 46	13 44	13 40	13 34	13 24	13 14	13 2
0 30	12 36	12 49	12 59	13 12	13 22	13 32	13 35	13 39	13 40	13 38	13 34	13 28	13 18	13 8	12 56
1 0	12 29	12 42	12 52	13 5	13 15	13 25	13 28	13 32	13 33	13 31	13 27	13 21	13 11	13 1	12 49
1 30	12 23	12 36	12 46	12 59	13 9	13 19	13 22	13 26	13 27	13 25	13 21	13 15	13 5	12 55	12 43
2 0	12 15	12 28	12 38	12 51	13 1	13 11	13 14	13 18	13 19	13 17	13 13	13 7	12 57	12 47	12 35
2 30	12 9	12 22	12 32	12 45	12 55	13 5	13 8	13 12	13 13	13 11	13 7	13 1	12 54	12 41	12 29
3 0	12 3	12 16	12 26	12 39	12 49	12 59	13 2	13 6	13 7	13 5	13 1	12 55	12 45	12 35	12 23
3 30	11 58	12 11	12 21	12 34	12 44	12 54	12 57	13 1	13 2	13 0	12 56	12 50	12 40	12 30	12 18
4 0	11 57	12 10	12 20	12 33	12 43	12 53	12 56	13 0	13 1	12 59	12 55	12 49	12 39	12 29	12 17
4 30	12 0	12 13	12 23	12 36	12 46	12 56	12 59	13 3	13 4	13 2	12 58	12 52	12 42	12 32	12 20
5 0	12 8	12 21	12 31	12 44	12 54	13 4	13 7	13 11	13 12	13 10	13 6	13 0	12 50	12 40	12 28
5 30	12 15	12 28	12 38	12 51	13 1	13 11	13 14	13 18	13 19	13 17	13 13	13 7	12 57	12 47	12 35
6 0	12 25	12 38	12 48	13 1	13 11	13 21	13 24	13 28	13 29	13 27	13 23	13 17	13 7	12 57	12 45
6 30	12 36	12 49	12 59	13 12	13 22	13 32	13 35	13 39	13 40	13 38	13 34	13 28	13 18	13 8	12 56
7 0	12 45	12 58	13 8	13 21	13 31	13 41	13 44	13 48	13 49	13 47	13 43	13 37	13 27	13 17	13 5
7 30	12 55	13 8	13 18	13 31	13 41	13 51	13 54	13 58	13 59	13 57	13 53	13 47	13 37	13 27	13 15
8 0	13 3	13 16	13 26	13 39	13 49	13 59	14 2	14 6	14 7	14 5	14 1	13 55	13 45	13 35	13 23
8 30	13 8	13 21	13 31	13 44	13 54	14 4	14 7	14 11	14 12	14 10	14 6	14 0	13 50	13 40	13 28
9 0	13 10	13 23	13 33	13 46	13 56	14 6	14 9	14 13	14 14	14 12	14 8	14 2	13 52	13 42	13 30
9 30	13 9	13 22	13 32	13 45	13 55	14 5	14 8	14 12	14 13	14 11	14 7	14 1	13 51	13 41	13 29
10 0	13 5	13 18	13 28	13 41	13 51	14 1	14 4	14 8	14 9	14 7	14 3	13 57	13 47	13 37	13 25
10 30	12 59	13 12	13 22	13 35	13 45	13 55	13 58	14 2	14 3	14 1	13 57	13 51	13 41	13 31	13 19
11 0	12 53	13 6	13 16	13 29	13 39	13 49	13 52	13 56	13 57	13 55	13 51	13 45	13 35	13 25	13 13
11 30	12 46	12 59	13 9	13 22	13 32	13 42	13 45	13 49	13 50	13 48	13 44	13 38	13 28	13 18	13 6

TABLE V.—ASTORIA.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—							0	After—						
	7	6	5	4	3	2	1		1	2	3	4	5	6	7
<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>
0 0	13 10	12 57	12 47	12 34	12 24	12 14	12 11	12 7	12 6	12 8	12 12	12 18	12 28	12 38	12 50
0 30	13 4	12 51	12 41	12 28	12 18	12 8	12 5	12 1	12 0	12 2	12 6	12 12	12 22	12 32	12 44
1 0	12 57	12 44	12 34	12 21	12 11	12 1	11 58	11 54	11 53	11 55	11 59	12 5	12 15	12 25	12 37
1 30	12 51	12 38	12 28	12 15	12 5	11 55	11 52	11 48	11 47	11 49	11 53	11 59	12 9	12 19	12 31
2 0	12 43	12 30	12 20	12 7	11 57	11 47	11 44	11 40	11 35	11 41	11 45	11 51	12 1	12 11	12 23
2 30	12 37	12 24	12 14	12 1	11 51	11 41	11 38	11 34	11 33	11 35	11 39	11 45	11 55	12 5	12 17
3 0	12 31	12 18	12 8	11 55	11 45	11 35	11 32	11 28	11 27	11 29	11 33	11 39	11 49	11 59	12 11
3 30	12 26	12 13	12 3	11 59	11 49	11 39	11 36	11 32	11 22	11 24	11 28	11 34	11 44	11 54	12 6
4 0	12 25	12 12	12 2	11 49	11 39	11 29	11 26	11 22	11 21	11 23	11 27	11 33	11 43	11 53	12 5
4 30	12 28	12 15	12 5	11 52	11 42	11 32	11 29	11 25	11 24	11 26	11 30	11 36	11 46	11 56	12 8
5 0	12 26	12 23	12 13	12 0	11 50	11 40	11 37	11 33	11 32	11 34	11 38	11 44	11 54	12 4	12 16
5 30	12 43	12 30	12 20	12 7	11 57	11 47	11 44	11 40	11 39	11 41	11 45	11 51	12 1	12 11	12 23
6 0	12 53	12 40	12 30	12 17	12 7	11 57	11 54	11 50	11 49	11 51	11 55	12 1	12 11	12 21	12 33
6 30	13 4	12 51	12 41	12 28	12 18	12 8	12 5	12 1	12 0	12 2	12 6	12 12	12 22	12 32	12 44
7 0	13 13	13 0	12 50	12 37	12 27	12 17	12 14	12 10	12 9	12 11	12 15	12 21	12 31	12 41	12 53
7 30	13 23	13 10	13 0	12 47	12 37	12 27	12 24	12 20	12 19	12 21	12 25	12 31	12 41	12 51	13 3
8 0	13 31	13 18	13 8	12 55	12 45	12 35	12 32	12 28	12 27	12 29	12 33	12 39	12 49	12 59	13 11
8 30	13 36	13 23	13 13	13 0	12 50	12 40	12 37	12 33	12 32	12 34	12 38	12 44	12 54	13 4	13 16
9 0	13 38	13 25	13 15	13 2	12 52	12 42	12 39	12 35	12 34	12 36	12 40	12 46	12 56	13 6	13 18
9 30	13 37	13 24	13 14	13 1	12 51	12 41	12 38	12 34	12 33	12 35	12 39	12 45	12 55	13 5	13 17
10 0	13 33	13 20	13 10	12 57	12 47	12 37	12 34	12 30	12 29	12 31	12 35	12 41	12 51	13 1	13 13
10 30	13 27	13 14	13 4	12 51	12 41	12 31	12 28	12 24	12 23	12 25	12 29	12 35	12 45	12 55	13 7
11 0	13 21	13 8	12 58	12 45	12 35	12 25	12 22	12 18	12 17	12 19	12 23	12 29	12 39	12 49	13 1
11 30	13 14	13 1	12 51	12 38	12 28	12 18	12 15	12 11	12 10	12 12	12 16	12 22	12 32	12 42	12 54

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TABLE IV.—PORT TOWNSHEND.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.															
	Before—								After—							
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>
0 0	3 45	3 21	2 51	2 2	1 32	1 13	1 26	1 44	2 2	2 21	2 42	2 57	3 15	3 33	3 45	
0 30	3 38	3 14	2 44	1 55	1 25	1 6	1 19	1 37	1 55	2 14	2 35	2 50	3 8	3 26	3 38	
1 0	3 32	3 8	2 38	1 49	1 19	1 0	1 13	1 31	1 49	2 8	2 29	2 44	3 2	3 20	3 32	
1 30	3 26	3 2	2 32	1 43	1 13	0 54	1 7	1 25	1 43	2 2	2 23	2 38	2 56	3 14	3 26	
2 0	3 21	2 57	2 27	1 38	1 8	0 49	1 2	1 20	1 38	1 57	2 18	2 33	2 51	3 9	3 21	
2 30	3 18	2 54	2 24	1 35	1 5	0 46	0 59	1 17	1 35	1 54	2 15	2 20	2 48	3 6	3 18	
3 0	3 16	2 52	2 22	1 33	1 3	0 44	0 57	1 15	1 33	1 52	2 13	2 28	2 46	3 4	3 16	
3 30	3 17	2 53	2 23	1 34	1 4	0 45	0 58	1 16	1 34	1 53	2 14	2 29	2 47	3 5	3 17	
4 0	3 21	2 57	2 27	1 38	1 8	0 49	1 2	1 20	1 38	1 57	2 18	2 33	2 51	3 9	3 21	
4 30	3 26	3 2	2 32	1 43	1 13	0 54	1 7	1 25	1 43	2 2	2 23	2 38	2 56	3 14	3 26	
5 0	3 32	3 8	2 38	1 49	1 19	1 0	1 13	1 31	1 49	2 8	2 29	2 44	3 2	3 20	3 32	
5 30	3 41	3 17	2 47	1 58	1 28	1 9	1 22	1 40	1 58	2 17	2 38	2 53	3 11	3 29	3 41	
6 0	3 52	3 28	2 58	2 9	1 39	1 20	1 33	1 51	2 9	2 28	2 49	3 4	3 22	3 40	3 52	
6 30	4 1	3 37	3 7	2 18	1 48	1 29	1 42	2 0	2 18	2 37	2 58	3 13	3 31	3 49	4 1	
7 0	4 8	3 44	3 14	2 25	1 55	1 36	1 49	2 7	2 25	2 44	3 5	3 20	3 38	3 56	4 8	
7 30	4 15	3 51	3 21	2 32	2 2	1 43	1 56	2 14	2 32	2 51	3 12	3 27	3 45	4 3	4 15	
8 0	4 18	3 54	3 24	2 35	2 5	1 46	1 59	2 17	2 35	2 54	3 15	3 30	3 48	4 6	4 18	
8 30	4 19	3 55	3 25	2 36	2 6	1 47	2 0	2 18	2 36	2 55	3 16	3 31	3 49	4 7	4 19	
9 0	4 18	3 54	3 24	2 35	2 5	1 46	1 59	2 17	2 35	2 54	3 15	3 30	3 48	4 6	4 18	
9 30	4 15	3 51	3 21	2 32	2 2	1 43	1 56	2 14	2 32	2 51	3 12	3 27	3 45	4 3	4 15	
10 0	4 10	3 46	3 16	2 27	1 57	1 38	1 51	2 9	2 27	2 46	3 7	3 22	3 40	3 58	4 10	
10 30	4 6	3 42	3 12	2 23	1 53	1 34	1 47	2 5	2 23	2 42	3 3	3 12	3 36	3 54	4 6	
11 0	4 0	3 36	3 6	2 17	1 47	1 28	1 41	1 59	2 17	2 36	2 57	3 12	3 30	3 48	4 0	
11 30	3 54	3 30	3 0	2 11	1 41	1 22	1 35	1 53	2 11	2 30	2 51	3 6	3 24	3 42	3 54	

TABLE V.—PORT TOWNSHEND.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.															
	Before—								After—							
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>
0 0	3 45	4 9	4 39	5 28	5 58	6 17	6 4	5 46	5 28	5 9	4 48	4 33	4 15	3 57	3 45	
0 30	3 38	4 2	4 32	5 21	5 51	6 10	5 57	5 39	5 21	5 2	4 41	4 26	4 8	3 50	3 38	
1 0	3 32	3 56	4 26	5 15	5 45	6 4	5 51	5 33	5 15	4 56	4 35	4 20	4 2	3 44	3 32	
1 30	3 26	3 50	4 20	5 9	5 39	5 58	5 45	5 27	5 9	4 50	4 29	4 14	3 56	3 38	3 26	
2 0	3 21	3 45	4 15	5 4	5 34	5 53	5 40	5 22	5 4	4 45	4 24	4 9	3 51	3 33	3 21	
2 30	3 18	3 42	4 12	5 1	5 31	5 50	5 37	5 19	5 1	4 42	4 21	4 6	3 48	3 30	3 18	
3 0	3 16	3 40	4 10	4 59	5 29	5 48	5 35	5 17	4 59	4 40	4 19	4 4	3 46	3 28	3 16	
3 30	3 17	3 41	4 11	5 0	5 30	5 49	5 36	5 18	5 0	4 41	4 20	4 5	3 47	3 29	3 17	
4 0	3 21	3 45	4 15	5 4	5 34	5 53	5 40	5 22	5 4	4 45	4 24	4 9	3 51	3 33	3 21	
4 30	3 26	3 50	4 20	5 9	5 39	5 58	5 45	5 27	5 9	4 50	4 29	4 14	3 56	3 38	3 26	
5 0	3 32	3 56	4 26	5 15	5 45	6 4	5 51	5 33	5 15	4 56	4 35	4 20	4 2	3 44	3 32	
5 30	3 41	4 5	4 35	5 24	5 54	6 13	6 0	5 42	5 24	5 5	4 44	4 29	4 11	3 53	3 41	
6 0	3 52	4 16	4 46	5 35	6 5	6 24	6 11	5 53	5 35	5 16	4 55	4 40	4 22	4 4	3 52	
6 30	4 1	4 25	4 55	5 44	6 14	6 33	6 20	6 2	5 44	5 25	5 4	4 49	4 31	4 13	4 1	
7 0	4 8	4 32	5 2	5 51	6 21	6 40	6 27	6 9	5 51	5 32	5 11	4 56	4 38	4 20	4 8	
7 30	4 15	4 39	5 9	5 58	6 28	6 47	6 34	6 16	5 58	5 39	5 18	5 3	4 45	4 27	4 15	
8 0	4 18	4 42	5 12	6 1	6 31	6 50	6 37	6 19	6 1	5 42	5 21	5 6	4 48	4 30	4 18	
8 30	4 19	4 43	5 13	6 2	6 32	6 51	6 38	6 20	6 2	5 43	5 22	5 7	4 49	4 31	4 19	
9 0	4 18	4 42	5 12	6 1	6 31	6 50	6 37	6 19	6 1	5 42	5 21	5 6	4 48	4 30	4 18	
9 30	4 15	4 39	5 9	5 58	6 28	6 47	6 34	6 16	5 58	5 39	5 18	5 3	4 45	4 27	4 15	
10 0	4 10	4 34	5 4	5 53	6 23	6 42	6 29	6 11	5 53	5 34	5 13	4 58	4 40	4 22	4 10	
10 30	4 6	4 30	5 0	5 49	6 19	6 38	6 25	6 7	5 49	5 30	5 9	4 54	4 36	4 18	4 6	
11 0	4 0	4 24	4 54	5 43	6 13	6 32	6 19	6 1	5 43	5 24	5 3	4 48	4 30	4 12	4 0	
11 30	3 54	4 18	4 48	5 37	6 7	6 26	6 13	5 55	5 37	5 18	4 57	4 42	4 24	4 6	3 54	

If we disregard the daily inequality, the column headed San Francisco in Table II would give us, as in the examples on the Atlantic coast, the means of determining the time of high water.

Example V.—Required, the time of high water at North Beach, San Francisco, California, on the 7th of February, 1853.

1st. The time of the moon's transit at Greenwich, from the Nautical Almanac, is 11*h.* 41*m.*; the longitude of San Francisco 8*h.* 10*m.*, requiring a correction of 16*m.* to the time of transit for San Francisco, which is thus found to be 11*h.* 57*m.*

2d. The moon's declination is south, and at the time of transit about two days after the greatest. Entering Table IV we find 12*h.* (or 0*h.*) of transit, the nearest number to 11*h.* 57*m.* which the table gives; and following the line horizontally until we come to two days after the greatest declination, we find 13*h.* 14*m.*

To 11*h.* 57*m.*, time of transit of the moon February 7, San Francisco, add 13*h.* 14*m.*, from column 0*h.*, transit, and two days after greatest declination; the sum, 25*h.* 11*m.*, or 1*h.* 11*m.*, February 8, is the time of high water, corresponding to the transit which we took of February 7. If we desire the tide of February 7 we must go back to the moon's transit of the 6th. The example was purposely assumed to show this case.

11*h.* 01*m.*, time of transit February 6, 1853.

13 31 number for 11*h.* transit, and one day from greatest declination.

Sum 24 32 time of high water 0*h.* 32*m.* a m., February 7.

The height of high water.—The height of high water is obtained in a similar manner by the use of Table VI and Table VII, entering these in the same way with the time of transit and days from the greatest declination. Table VI is for south declination, and Table VII for north.

TABLE VI.—KEY WEST.

Time of moon's transit.		SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
		Before—							After—							
		7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
0	1.5	1.6	1.8	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.8	1.7	1.5
1	1.5	1.6	1.8	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.8	1.7	1.5
2	1.5	1.6	1.8	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.8	1.7	1.5
3	1.4	1.5	1.7	1.8	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.8	1.7	1.6	1.4
4	1.3	1.4	1.6	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.7	1.6	1.5	1.3
5	1.2	1.3	1.5	1.6	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.6	1.5	1.4	1.2
6	1.1	1.2	1.4	1.5	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.5	1.4	1.3	1.1
7	1.1	1.2	1.4	1.5	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.5	1.4	1.3	1.1
8	1.2	1.3	1.5	1.6	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.6	1.5	1.4	1.2
9	1.3	1.4	1.6	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.7	1.6	1.5	1.3
10	1.4	1.5	1.7	1.8	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.8	1.7	1.6	1.4
11	1.5	1.6	1.8	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.8	1.7	1.5

TABLE VII.—KEY WEST.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—							0	After—						
	7	6	5	4	3	2	1		1	2	3	4	5	6	7
Hour.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
0	1.7	1.6	1.4	1.3	1.2	1.1	1.0	1.0	1.1	1.1	1.2	1.3	1.4	1.6	1.8
1	1.7	1.6	1.4	1.3	1.2	1.1	1.0	1.0	1.1	1.1	1.2	1.3	1.4	1.6	1.8
2	1.7	1.6	1.4	1.3	1.2	1.1	1.0	1.0	1.1	1.1	1.2	1.3	1.4	1.6	1.8
3	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.9	1.0	1.0	1.1	1.2	1.3	1.5	1.7
4	1.5	1.4	1.2	1.1	1.0	0.9	0.8	0.8	0.9	0.9	1.0	1.1	1.2	1.4	1.6
5	1.4	1.3	1.1	1.0	0.9	0.8	0.7	0.7	0.8	0.8	0.9	1.0	1.1	1.3	1.5
6	1.3	1.2	1.0	0.9	0.8	0.7	0.6	0.6	0.7	0.7	0.8	0.9	1.0	1.2	1.4
7	1.3	1.2	1.0	0.9	0.8	0.7	0.6	0.6	0.7	0.7	0.8	0.9	1.0	1.2	1.4
8	1.4	1.3	1.1	1.0	0.9	0.8	0.7	0.7	0.8	0.8	0.9	1.0	1.1	1.3	1.5
9	1.5	1.4	1.2	1.1	1.0	0.9	0.8	0.8	0.9	0.9	1.0	1.1	1.2	1.4	1.6
10	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.9	1.0	1.0	1.1	1.2	1.3	1.5	1.7
11	1.7	1.6	1.4	1.3	1.2	1.1	1.0	1.0	1.1	1.1	1.2	1.3	1.4	1.6	1.8

TABLE VI.—SAN DIEGO.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—							0	After—						
	7	6	5	4	3	2	1		1	2	3	4	5	5	7
Hour.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
0	4.7	4.5	4.3	4.2	4.1	4.1	4.1	4.1	4.2	4.3	4.5	4.8	5.1	5.5	5.8
1	4.6	4.4	4.2	4.1	4.0	4.0	4.0	4.0	4.1	4.2	4.4	4.7	5.0	5.4	5.7
2	4.4	4.2	4.0	3.9	3.8	3.8	3.8	3.8	3.9	4.0	4.2	4.5	4.8	5.2	5.5
3	4.1	3.9	3.7	3.6	3.5	3.5	3.5	3.5	3.6	3.7	3.9	4.2	4.5	4.9	5.2
4	3.8	3.6	3.4	3.3	3.2	3.2	3.2	3.2	3.3	3.4	3.6	3.9	4.2	4.6	4.9
5	3.6	3.4	3.2	3.1	3.0	3.0	3.0	3.0	3.1	3.2	3.4	3.7	4.0	4.4	4.7
6	3.6	3.4	3.2	3.1	3.0	3.0	3.0	3.0	3.1	3.2	3.4	3.7	4.0	4.4	4.7
7	3.7	3.5	3.3	3.2	3.1	3.1	3.1	3.1	3.2	3.3	3.5	3.8	4.1	4.5	4.8
8	3.8	3.6	3.4	3.3	3.2	3.2	3.2	3.2	3.3	3.4	3.6	3.9	4.2	4.6	4.9
9	4.4	4.2	4.0	3.9	3.8	3.8	3.8	3.8	3.9	4.0	4.2	4.5	4.8	5.2	5.5
10	4.7	4.5	4.3	4.2	4.1	4.1	4.1	4.1	4.2	4.3	4.5	4.8	5.1	5.5	5.8
11	4.8	4.6	4.4	4.3	4.2	4.2	4.2	4.2	4.3	4.4	4.6	4.9	5.2	5.6	5.9

TABLE VII.—SAN DIEGO.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—							0	After—						
	7	6	5	4	3	2	1		1	2	3	4	5	6	7
Hour.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
0	5.7	5.9	6.1	6.2	6.3	6.3	6.3	6.3	6.2	6.1	5.9	5.6	5.3	4.9	4.6
1	5.6	5.8	6.0	6.1	6.2	6.2	6.2	6.2	6.1	6.0	5.8	5.5	5.2	4.8	4.5
2	5.4	5.6	5.8	5.9	6.0	6.0	6.0	6.0	5.9	5.8	5.6	5.3	5.0	4.6	4.3
3	5.1	5.3	5.5	5.6	5.7	5.7	5.7	5.7	5.6	5.5	5.3	5.0	4.7	4.3	4.0
4	4.8	5.0	5.2	5.3	5.4	5.4	5.4	5.4	5.3	5.2	5.0	4.7	4.4	4.0	3.7
5	4.6	4.8	5.0	5.1	5.2	5.2	5.2	5.2	5.1	5.0	4.8	4.5	4.2	3.8	3.5
6	4.6	4.8	5.0	5.1	5.2	5.2	5.2	5.2	5.1	5.0	4.8	4.5	4.2	3.8	3.5
7	4.7	4.9	5.1	5.2	5.3	5.3	5.3	5.3	5.2	5.1	4.9	4.6	4.3	3.9	3.6
8	4.8	5.0	5.2	5.3	5.4	5.4	5.4	5.4	5.3	5.2	5.0	4.7	4.4	4.0	3.7
9	5.4	5.6	5.8	5.9	6.0	6.0	6.0	6.0	5.9	5.8	5.6	5.3	5.0	4.6	4.3
10	5.7	5.9	6.1	6.2	6.3	6.3	6.3	6.3	6.2	6.1	5.9	5.6	5.3	4.9	4.6
11	5.8	6.0	6.2	6.3	6.4	6.4	6.4	6.4	6.3	6.2	6.0	5.7	5.4	5.0	4.7

REPORT OF THE SUPERINTENDENT OF

TABLE VI.—SAN FRANCISCO.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—							0	After—						
	7	6	5	4	3	2	1		1	2	3	4	5	6	7
Hour.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.
0	4.8	4.7	4.5	4.3	4.3	4.2	4.3	4.3	4.4	4.5	4.7	4.8	5.0	5.3	5.5
1	4.7	4.6	4.4	4.2	4.2	4.1	4.2	4.2	4.3	4.4	4.6	4.7	4.9	5.2	5.4
2	4.6	4.5	4.3	4.1	4.1	4.0	4.1	4.1	4.2	4.3	4.5	4.6	4.8	5.1	5.3
3	4.5	4.4	4.2	4.0	4.0	3.9	4.0	4.0	4.1	4.2	4.4	4.5	4.7	5.0	5.2
4	4.3	4.2	4.0	3.8	3.8	3.7	3.8	3.8	3.9	4.0	4.2	4.3	4.5	4.8	5.0
5	4.1	4.0	3.8	3.6	3.6	3.5	3.6	3.6	3.7	3.8	4.0	4.1	4.3	4.6	4.8
6	4.1	4.0	3.8	3.6	3.6	3.5	3.6	3.6	3.7	3.8	4.0	4.1	4.3	4.6	4.8
7	4.2	4.1	3.9	3.7	3.7	3.6	3.7	3.7	3.8	3.9	4.1	4.2	4.4	4.7	4.9
8	4.4	4.3	4.1	3.9	3.9	3.8	3.9	3.9	4.0	4.1	4.3	4.4	4.6	4.9	5.1
9	4.5	4.4	4.2	4.0	4.0	3.9	4.0	4.0	4.1	4.2	4.4	4.5	4.7	5.0	5.2
10	4.7	4.6	4.4	4.2	4.2	4.1	4.2	4.2	4.3	4.4	4.6	4.7	4.9	5.2	5.4
11	4.8	4.7	4.5	4.3	4.3	4.2	4.3	4.3	4.4	4.5	4.7	4.8	5.0	5.3	5.5

TABLE VII.—SAN FRANCISCO.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—							0	After—						
	7	6	5	4	3	2	1		1	2	3	4	5	6	7
Hour.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.
0	5.4	5.5	5.7	5.9	5.9	6.0	5.9	5.9	5.8	5.7	5.5	5.4	5.2	4.9	4.7
1	5.3	5.4	5.6	5.8	5.8	5.9	5.8	5.8	5.7	5.6	5.4	5.3	5.1	4.8	4.6
2	5.2	5.3	5.5	5.7	5.7	5.8	5.7	5.7	5.6	5.5	5.3	5.2	5.0	4.7	4.5
3	5.1	5.2	5.4	5.6	5.6	5.7	5.6	5.6	5.5	5.4	5.2	5.1	4.9	4.6	4.4
4	4.9	5.0	5.2	5.4	5.4	5.5	5.4	5.4	5.3	5.2	5.0	4.9	4.7	4.4	4.2
5	4.7	4.8	5.0	5.2	5.2	5.3	5.2	5.2	5.1	5.0	4.8	4.7	4.5	4.2	4.0
6	4.7	4.8	5.0	5.2	5.2	5.3	5.2	5.2	5.1	5.0	4.8	4.7	4.5	4.2	4.0
7	4.8	4.9	5.1	5.3	5.3	5.4	5.3	5.3	5.2	5.1	4.9	4.8	4.6	4.3	4.1
8	5.0	5.1	5.3	5.5	5.5	5.6	5.5	5.5	5.4	5.3	5.1	5.0	4.8	4.5	4.3
9	5.1	5.2	5.4	5.6	5.6	5.7	5.6	5.6	5.5	5.4	5.2	5.1	4.9	4.6	4.4
10	5.3	5.4	5.6	5.8	5.8	5.9	5.8	5.8	5.7	5.6	5.4	5.3	5.1	4.8	4.6
11	5.4	5.5	5.7	5.9	5.9	6.0	5.9	5.9	5.8	5.7	5.5	5.4	5.2	4.9	4.7

TABLE VI.—ASTORIA.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—							0	After—						
	7	6	5	4	3	2	1		1	2	3	4	5	6	7
Hour.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.	Fect.
0	8.0	8.3	8.4	8.5	8.6	8.6	8.6	8.6	8.5	8.4	8.3	8.1	7.7	7.4	7.0
1	8.0	8.2	8.4	8.5	8.6	8.6	8.6	8.6	8.5	8.4	8.2	8.1	7.7	7.4	7.0
2	7.8	8.1	8.2	8.4	8.4	8.4	8.4	8.4	8.3	8.2	8.1	7.9	7.5	7.2	6.8
3	7.5	7.8	7.9	8.1	8.1	8.1	8.1	8.1	8.0	7.9	7.8	7.6	7.2	6.9	6.5
4	7.1	7.4	7.5	7.7	7.7	7.7	7.7	7.7	7.6	7.5	7.4	7.2	6.8	6.5	6.1
5	6.7	7.0	7.2	7.3	7.3	7.3	7.3	7.3	7.2	7.1	7.0	6.8	6.5	6.1	5.7
6	6.5	6.8	7.0	7.1	7.1	7.1	7.1	7.1	7.0	6.9	6.8	6.6	6.3	5.9	5.5
7	6.7	7.0	7.1	7.2	7.3	7.3	7.3	7.3	7.2	7.1	7.0	6.8	6.4	6.1	5.7
8	7.0	7.3	7.5	7.6	7.6	7.6	7.6	7.6	7.5	7.4	7.3	7.1	6.8	6.4	6.0
9	7.5	7.8	8.0	8.1	8.1	8.1	8.1	8.1	8.0	7.9	7.8	7.6	7.3	6.9	6.5
10	7.9	8.2	8.4	8.5	8.5	8.5	8.5	8.5	8.4	8.3	8.2	8.0	7.7	7.3	6.9
11	8.1	8.4	8.6	8.7	8.7	8.7	8.7	8.7	8.6	8.5	8.4	8.2	7.9	7.5	7.1

TABLE VII.—ASTORIA.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—							0	After—						
	7	6	5	4	3	2	1		1	2	3	4	5	6	7
Hour.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
0	7.4	7.1	6.9	6.8	6.8	6.8	6.8	6.8	6.9	7.0	7.1	7.3	7.6	8.0	8.4
1	7.4	7.1	6.9	6.8	6.8	6.8	6.8	6.8	6.9	7.0	7.1	7.3	7.6	8.0	8.4
2	7.2	6.9	6.8	6.6	6.6	6.6	6.6	6.6	6.7	6.8	6.9	7.1	7.5	7.8	8.2
3	6.9	6.6	6.5	6.3	6.3	6.3	6.3	6.3	6.4	6.5	6.6	6.8	7.2	7.5	7.9
4	6.5	6.2	6.1	5.9	5.9	5.9	5.9	5.9	6.0	6.1	6.2	6.4	6.7	7.1	7.5
5	6.1	5.9	5.7	5.6	5.5	5.5	5.5	5.6	5.7	5.7	5.9	6.0	6.4	6.7	7.1
6	5.9	5.7	5.5	5.4	5.3	5.3	5.3	5.4	5.5	5.5	5.7	5.9	6.2	6.5	6.9
7	6.1	5.8	5.6	5.5	5.5	5.5	5.5	5.5	5.6	5.7	5.8	6.0	6.3	6.7	7.1
8	6.4	6.2	6.0	5.9	5.8	5.8	5.8	5.8	5.9	6.0	6.2	6.3	6.7	7.0	7.4
9	6.9	6.7	6.5	6.4	6.3	6.3	6.3	6.4	6.4	6.5	6.7	6.8	7.2	7.5	7.9
10	7.3	7.1	6.9	6.8	6.7	6.7	6.7	6.8	6.9	6.9	7.0	7.2	7.6	7.9	8.3
11	7.5	7.2	7.1	7.0	6.9	6.9	6.9	6.9	7.0	7.1	7.2	7.4	7.8	8.1	8.5

TABLE VI.—PORT TOWNSHEND.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—							0	After—						
	7	6	5	4	3	2	1		1	2	3	4	5	6	7
Hour.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
0	6.6	6.3	5.9	6.1	6.4	6.9	7.2	7.4	7.5	7.5	7.5	7.5	7.6	7.7	7.9
1	6.7	6.4	6.0	6.2	6.5	7.0	7.3	7.5	7.6	7.6	7.6	7.6	7.7	7.8	8.0
2	6.6	6.3	5.9	6.1	6.4	6.9	7.2	7.4	7.5	7.5	7.5	7.5	7.6	7.7	7.9
3	6.3	6.0	5.6	5.8	6.1	6.6	6.9	7.1	7.2	7.2	7.2	7.2	7.3	7.4	7.6
4	6.0	5.7	5.3	5.5	5.8	6.3	6.6	6.8	6.9	6.9	6.9	6.9	7.0	7.1	7.3
5	5.9	5.6	5.2	5.4	5.7	6.2	6.5	6.7	6.8	6.8	6.8	6.8	6.9	7.0	7.2
6	6.1	5.8	5.4	5.6	5.9	6.4	6.7	6.9	7.0	7.0	7.0	7.0	7.1	7.2	7.4
7	6.4	6.1	5.7	5.9	6.2	6.7	7.0	7.2	7.3	7.3	7.3	7.3	7.4	7.5	7.7
8	6.5	6.2	5.8	6.0	6.3	6.8	7.1	7.3	7.4	7.4	7.4	7.4	7.5	7.6	7.8
9	6.5	6.2	5.8	6.0	6.3	6.8	7.1	7.3	7.4	7.4	7.4	7.4	7.5	7.6	7.8
10	6.6	6.3	5.9	6.1	6.4	6.9	7.2	7.4	7.5	7.5	7.5	7.5	7.6	7.7	7.9
11	6.6	6.3	5.9	6.1	6.4	6.9	7.2	7.4	7.5	7.5	7.5	7.5	7.6	7.7	7.9

TABLE VII.—PORT TOWNSHEND.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—							0	After—						
	7	6	5	4	3	2	1		1	2	3	4	5	6	7
Hour.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
0	7.6	7.9	8.3	8.1	7.8	7.3	7.0	6.8	6.7	6.7	6.7	6.7	6.6	6.5	6.3
1	7.7	8.0	8.4	8.2	7.9	7.4	7.1	6.9	6.8	6.8	6.8	6.8	6.7	6.6	6.4
2	7.6	7.9	8.3	8.1	7.8	7.3	7.0	6.8	6.7	6.7	6.7	6.7	6.6	6.5	6.3
3	7.3	7.6	8.0	7.8	7.5	7.0	6.7	6.5	6.4	6.4	6.4	6.4	6.3	6.2	6.0
4	7.0	7.3	7.7	7.5	7.2	6.7	6.4	6.2	6.1	6.1	6.1	6.1	6.0	5.9	5.7
5	6.9	7.2	7.6	7.4	7.1	6.6	6.3	6.1	6.0	6.0	6.0	6.0	5.9	5.8	5.6
6	7.1	7.4	7.8	7.6	7.3	6.8	6.5	6.3	6.2	6.2	6.2	6.2	6.1	6.0	5.8
7	7.4	7.7	8.1	7.9	7.6	7.1	6.8	6.6	6.5	6.5	6.5	6.5	6.4	6.3	6.1
8	7.5	7.8	8.2	8.0	7.7	7.2	6.9	6.7	6.6	6.6	6.6	6.6	6.5	6.4	6.2
9	7.5	7.8	8.2	8.0	7.7	7.2	6.9	6.7	6.6	6.6	6.6	6.6	6.5	6.4	6.2
10	7.6	7.9	8.3	8.1	7.8	7.3	7.0	6.8	6.7	6.7	6.7	6.7	6.6	6.5	6.3
11	7.6	7.9	8.3	8.1	7.8	7.3	7.0	6.8	6.7	6.7	6.7	6.7	6.6	6.5	6.3

NOTE.—To use these tables with a chart on which the soundings are referred to mean low water, subtract 1.2 foot from the numbers in the tables from San Diego to Astoria, 1.7 foot for Nee-ah harbor, 2.3 for Port Townshend, and 2.7 for Sumiahmoo and Steilacoom.

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Example VI.—In Example V, to obtain the height of tide on February 7, the declination being south, we enter Table VI for San Francisco, with 0% of transit, and two days after greatest declination, and find that the tide will be 4.5 feet above the mean of the lowest low water, or that 4.5 feet are to be added to the soundings of a chart reduced to the mean of the lowest low waters of each day. If the soundings of the chart are given for mean low water, then 1.2 feet ought to be subtracted from the Table VI and VII; thus, in this example, it would be 3.3 feet.

The approximate time of the successive low and high waters of the day will be found by adding the numbers in Table VIII to the time of the first high water already determined. The table gives the numbers for the different days from the greatest declination.

Tables containing numbers to be added to the time of high water found from Tables IV and V, to obtain the successive high and low waters.

TABLE VIII.—KEY WEST.

Days from moon's greatest declination.	SOUTH DECLINATION.			NORTH DECLINATION.			Days from moon's greatest declination.
	Low water. (Large.)	High water. (Small.)	Low water. (Small.)	Low water. (Small.)	High water. (Large.)	Low water. (Large.)	
	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	
Before.	7	5 22	12 10	17 38	5 36	12 33	7
	6	5 42	12 31	17 40	5 18	12 18	6
	5	6 05	12 55	17 41	4 58	12 03	5
	4	6 24	13 17	17 44	4 35	11 44	4
	3	6 39	13 28	17 39	4 11	11 18	3
	2	7 02	13 52	17 40	3 50	10 58	2
	1	7 13	14 01	17 39	3 39	10 46	1
After.	0	7 18	14 10	17 42	3 37	10 46	0
	1	7 12	14 10	17 48	3 44	10 46	1
	2	6 57	13 58	17 51	3 57	10 54	2
	3	6 39	13 41	17 53	4 21	11 19	3
	4	6 15	13 18	17 53	4 43	11 38	4
	5	5 57	12 59	17 53	5 09	12 03	5
	6	5 32	12 36	17 54	5 26	12 22	6
	7	5 13	12 16	17 53	5 40	12 36	7

TABLE VIII.—SAN DIEGO.

Days from moon's greatest declination.	SOUTH DECLINATION.			NORTH DECLINATION.			Days from moon's greatest declination.
	Low water. (Small.)	High water. (Large.)	Low water. (Large.)	Low water. (Large.)	High water. (Small.)	Low water. (Small.)	
	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	
Before.	7	5 44	12 28	18 44	6 16	12 16	7
	6	5 18	11 58	18 40	6 42	12 46	6
	5	5 00	11 34	18 34	7 00	13 10	5
	4	4 47	11 12	18 25	7 13	13 32	4
	3	4 34	10 54	18 20	7 26	13 50	3
	2	4 24	10 38	18 14	7 36	14 06	2
	1	4 17	10 28	18 11	7 43	14 16	1
After.	0	4 12	10 20	18 08	7 48	14 24	0
	1	4 14	10 20	18 06	7 46	14 24	1
	2	4 24	10 28	18 04	7 36	14 16	2
	3	4 38	10 40	18 02	7 22	14 04	3
	4	5 01	10 58	17 57	6 59	13 46	4
	5	5 25	11 18	17 53	6 35	13 26	5
	6	5 49	11 44	17 55	6 11	13 00	6
	7	6 18	12 18	18 00	5 42	12 26	7

TABLE VIII.—SAN FRANCISCO.

Days from moon's greatest declination.	SOUTH DECLINATION			NORTH DECLINATION.			Days from moon's greatest declination.
	Low water. (Small.)	High water. (Large.)	Low water. (Large.)	Low water. (Large.)	High water. (Small.)	Low water. (Small.)	
Before.	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	Before.
	7 5 58	13 14	18 58	5 44	11 46	17 44	
	6 5 36	12 42	18 48	6 06	12 18	17 54	
	5 5 14	12 10	18 38	6 28	12 50	18 04	
	4 4 55	11 34	18 21	6 47	13 26	18 21	
	3 4 37	11 00	18 05	7 05	14 00	18 37	
	2 4 24	10 34	17 52	7 18	14 26	18 50	
After.	1 4 12	10 06	17 36	7 30	14 54	19 06	After.
	0 4 12	10 00	17 30	7 30	15 00	19 12	
	1 4 17	10 02	17 27	7 25	14 58	19 15	
	2 4 27	10 12	17 27	7 15	14 48	19 15	
	3 4 41	10 26	17 27	7 01	14 34	19 15	
	4 4 56	10 46	17 32	6 46	14 14	19 10	
	5 5 14	11 10	17 38	6 28	13 50	19 04	
	6 5 36	11 36	17 42	6 06	13 24	19 00	
	7 5 57	12 04	17 49	5 45	12 56	18 53	

TABLE VIII.—ASTORIA.

Days from moon's greatest declination.	SOUTH DECLINATION.			NORTH DECLINATION.			Days from moon's greatest declination.
	Low water. (Small.)	High water. (Large.)	Low water. (Large.)	Low water. (Large.)	High water. (Small.)	Low water. (Small.)	
Before.	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	Before.
	7 6 38	12 59	19 17	6 18	12 03	18 41	
	6 6 14	12 33	19 15	6 42	12 29	18 43	
	5 5 55	12 13	19 14	7 01	12 49	18 44	
	4 5 34	11 47	19 09	7 22	13 15	18 49	
	3 5 20	11 27	19 03	7 36	13 35	18 55	
	2 5 09	11 07	18 54	7 47	13 55	19 04	
After.	1 5 05	11 01	18 52	7 51	14 01	19 06	After.
	0 5 03	10 53	18 46	7 53	14 09	19 12	
	1 5 05	10 51	18 43	7 51	14 11	19 16	
	2 5 11	10 55	18 40	7 45	14 07	19 18	
	3 5 18	11 03	18 41	7 38	13 59	19 17	
	4 5 32	11 15	18 39	7 24	13 47	19 19	
	5 5 50	11 35	18 41	7 06	13 27	19 17	
	6 6 11	11 55	18 40	6 45	13 07	19 18	
	7 6 35	12 19	18 40	6 21	12 43	19 18	

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TABLE VIII.—PORT TOWNSHEND.

Days from moon's greatest declina- tion.	SOUTH DECLINATION.			NORTH DECLINATION.			Days from moon's greatest declina- tion.
	Low water.	High water.	Low water.	Low water.	High water.	Low water.	
Before.	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	Before.
	7	6 05	12 26	18 05	5 39	12 25	
	6	6 38	13 14	18 20	5 06	11 38	
	5	7 18	14 14	18 40	4 26	10 38	
	4	8 13	15 52	19 23	3 31	9 00	
	3	8 36	16 52	20 00	3 08	8 00	
	2	8 43	17 30	20 31	3 01	7 22	
After.	1	8 12	17 04	20 36	3 32	7 48	After.
	0	7 40	16 28	20 32	4 04	8 24	
	1	7 18	15 52	20 18	4 26	9 00	
	2	6 59	15 14	19 59	4 45	9 38	
	3	6 38	14 32	19 38	5 06	10 20	
	4	6 24	14 02	19 22	5 20	10 50	
	5	6 10	13 26	19 00	5 34	11 26	
	6	5 59	12 50	18 35	5 45	12 02	
	7	5 42	12 26	18 28	6 02	12 26	

The days from the greatest declination are written in the first and last columns of the table. The second, third, and fourth columns refer to south declination, and fifth, sixth, and seventh to north, and the reverse for Key West. The second column gives the number which is to be added, according to the declination, to the time of high water, obtained by means of Tables IV and V, to give the next low water, which is the small low water, *b*, of diagram I. The third contains the numbers to be added to the same to give the second or large high water, *c*, of diagram I. The fourth, the numbers to be added to the same to give the second or large low water, *d*, of diagram I. The succeeding columns give the numbers to be used in the same way for north declination to obtain the low water, *b*, (large,) of diagram II; the high water, *c*, (small,) and the low water, *d*, (small,) of the same diagram. The rise and fall of the same successive tides may be obtained by inspection from Table IX, in which the first column at the side contains the time of transit, and the successive columns the numbers corresponding to that time and to the number of days from greatest declination. The arrangement of this table is like that already given.

The numbers for the small ebb tide, *a b*, of diagram I, or *c d*, of diagram II, are first given; then those for small low and large high waters, *b c*, of diagram I, and *d e*, of diagram II; next, the large ebb tide, *c d*, of diagram I, or *a b*, of diagram II; and lastly, from the large low water to the small high water, *d e*, of diagram I, or *b c*, of diagram II.

TABLE IX.—KEY WEST.

Time of moon's transit.	SMALL EBB TIDE.																SMALL LOW TO LARGE HIGH WATER.																Time of moon's transit.
	Days from moon's greatest declination.																Days from moon's greatest declination.																
	Before—								After—								Before—								After—								
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7			
	<i>H.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>H.</i>		
0	1.6	1.4	1.1	1.0	0.8	0.7	0.7	0.7	0.7	0.7	0.8	0.9	1.1	1.2	1.5	1.8	1.4	1.4	1.5	1.6	1.6	1.7	1.7	1.7	1.7	1.6	1.7	1.7	1.6	1.5	1.4	0	
1	1.6	1.4	1.1	1.0	0.8	0.7	0.7	0.7	0.7	0.7	0.8	0.9	1.1	1.2	1.5	1.8	1.4	1.4	1.5	1.6	1.6	1.7	1.7	1.7	1.7	1.6	1.7	1.7	1.6	1.5	1.4	1	
2	1.6	1.4	1.1	1.0	0.8	0.7	0.7	0.7	0.7	0.7	0.8	0.9	1.1	1.2	1.5	1.8	1.4	1.4	1.5	1.6	1.6	1.7	1.7	1.7	1.7	1.6	1.7	1.7	1.6	1.5	1.4	2	
3	1.5	1.3	1.0	0.9	0.7	0.6	0.6	0.6	0.6	0.6	0.7	0.8	1.0	1.1	1.4	1.7	1.3	1.3	1.4	1.5	1.5	1.6	1.6	1.6	1.6	1.5	1.6	1.6	1.5	1.4	1.3	3	
4	1.3	1.1	0.8	0.7	0.5	0.4	0.4	0.4	0.4	0.4	0.5	0.6	0.8	0.9	1.2	1.5	1.1	1.1	1.2	1.3	1.3	1.4	1.4	1.4	1.4	1.3	1.4	1.4	1.3	1.2	1.1	4	
5	1.1	0.9	0.6	0.5	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.4	0.6	0.7	1.0	1.3	0.9	0.9	1.0	1.1	1.1	1.2	1.2	1.2	1.2	1.1	1.2	1.2	1.1	1.0	0.9	5	
6	1.0	0.8	0.5	0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.5	0.6	0.9	1.2	0.8	0.8	0.9	1.0	1.0	1.1	1.1	1.1	1.1	1.0	1.1	1.1	1.0	0.9	0.8	6	
7	1.0	0.8	0.5	0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.5	0.6	0.9	1.2	0.8	0.8	0.9	1.0	1.0	1.1	1.1	1.1	1.1	1.0	1.1	1.1	1.0	0.9	0.8	7	
8	1.1	0.9	0.6	0.5	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.4	0.6	0.7	1.0	1.3	0.9	0.9	1.0	1.1	1.1	1.2	1.2	1.2	1.2	1.1	1.2	1.2	1.1	1.0	0.9	8	
9	1.3	1.1	0.8	0.7	0.5	0.4	0.4	0.4	0.4	0.4	0.5	0.6	0.8	0.9	1.2	1.5	1.1	1.1	1.2	1.3	1.3	1.4	1.4	1.4	1.4	1.3	1.4	1.4	1.3	1.2	1.1	9	
10	1.5	1.3	1.0	0.9	0.7	0.6	0.6	0.6	0.6	0.6	0.7	0.8	1.0	1.1	1.4	1.7	1.3	1.3	1.4	1.5	1.5	1.6	1.6	1.6	1.6	1.5	1.6	1.6	1.5	1.4	1.3	10	
11	1.6	1.4	1.1	1.0	0.8	0.7	0.7	0.7	0.7	0.7	0.8	0.9	1.1	1.2	1.5	1.8	1.4	1.4	1.5	1.6	1.6	1.7	1.7	1.7	1.7	1.6	1.7	1.7	1.6	1.5	1.4	11	

TABLE IX.—KEY WEST—Continued.

Time of moon's transit.	LARGE EBB TIDE.																LARGE LOW TO SMALL HIGH WATER.																Time of moon's transit.
	Days from moon's greatest declination.																Days from moon's greatest declination.																
	Before—							0	After—							Before—							0	After—									
	7	6	5	4	3	2	1		1	2	3	4	5	6	7	7	6	5	4	3	2	1		1	2	3	4	5	6	7			
H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	H.				
0	1.4	1.6	1.9	2.0	2.2	2.3	2.3	2.3	2.3	2.2	2.1	1.9	1.8	1.5	1.2	1.6	1.5	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.4	1.3	1.3	1.4	1.5	1.6	0		
1	1.4	1.6	1.9	2.0	2.2	2.3	2.3	2.3	2.3	2.2	2.1	1.9	1.8	1.5	1.2	1.6	1.5	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.4	1.3	1.3	1.4	1.5	1.6	1		
2	1.4	1.6	1.9	2.0	2.2	2.3	2.3	2.3	2.3	2.2	2.1	1.9	1.8	1.5	1.2	1.6	1.5	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.4	1.3	1.3	1.4	1.5	1.6	2		
3	1.3	1.5	1.8	1.9	2.1	2.2	2.2	2.2	2.2	2.1	2.0	1.8	1.7	1.4	1.1	1.5	1.4	1.4	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.4	1.5	3		
4	1.1	1.3	1.6	1.7	1.9	2.0	2.0	2.0	2.0	1.9	1.8	1.6	1.5	1.2	0.9	1.3	1.2	1.2	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.1	1.0	1.0	1.1	1.2	1.3	4	
5	0.9	1.1	1.4	1.5	1.7	1.8	1.8	1.8	1.8	1.7	1.6	1.4	1.3	1.0	0.7	1.1	1.0	1.0	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.9	0.8	0.8	0.9	1.0	1.1	5	
6	0.8	1.0	1.3	1.4	1.6	1.7	1.7	1.7	1.7	1.6	1.5	1.3	1.2	0.9	0.6	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.8	0.7	0.7	0.8	0.9	1.0	6	
7	0.8	1.0	1.3	1.4	1.6	1.7	1.7	1.7	1.7	1.6	1.5	1.3	1.2	0.9	0.6	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.8	0.7	0.7	0.8	0.9	1.0	7	
8	0.9	1.1	1.4	1.5	1.7	1.8	1.8	1.8	1.8	1.7	1.6	1.4	1.3	1.0	0.7	1.1	1.0	1.0	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.9	0.8	0.8	0.9	1.0	1.1	8	
9	1.1	1.3	1.6	1.7	1.9	2.0	2.0	2.0	2.0	1.9	1.8	1.6	1.5	1.2	0.9	1.3	1.2	1.2	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.1	1.0	1.0	1.1	1.2	1.3	9	
10	1.3	1.5	1.8	1.9	2.1	2.2	2.2	2.2	2.2	2.1	2.0	1.8	1.7	1.4	1.1	1.5	1.4	1.4	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.3	1.2	1.2	1.3	1.4	1.5	10	
11	1.4	1.6	1.9	2.0	2.2	2.3	2.3	2.3	2.3	2.2	2.1	1.9	1.8	1.5	1.2	1.6	1.5	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.4	1.3	1.3	1.4	1.5	1.6	11	

REPORT OF THE SUPERINTENDENT OF

TABLE IX.—SAN DIEGO.

Time of moon's transit.	SMALL EBB TIDE, OR FROM SMALL HIGH WATER TO SMALL LOW WATER.																FROM SMALL LOW WATER TO LARGE HIGH WATER.																Time of moon's transit.
	Days from moon's greatest declination.																Days from moon's greatest declination.																
	Before—								After—								Before—								After—								
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7			
H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	H.			
0	4.0	3.4	3.0	2.6	2.3	2.1	2.0	2.0	2.1	2.3	2.7	3.2	3.8	4.6	5.2	5.1	4.9	4.7	4.5	4.4	4.3	4.2	4.2	4.1	4.1	4.0	4.0	3.9	3.9	4.0	0		
1	3.8	3.2	2.8	2.4	2.1	1.9	1.8	1.8	1.9	2.1	2.5	3.0	3.6	4.4	5.0	4.9	4.7	4.5	4.3	4.2	4.1	4.0	4.0	3.9	3.9	3.8	3.8	3.7	3.7	3.8	1		
2	3.5	2.9	2.5	2.1	1.8	1.6	1.5	1.5	1.6	1.8	2.2	2.7	3.3	4.1	4.7	4.6	4.4	4.2	4.0	3.9	3.8	3.7	3.7	3.6	3.6	3.5	3.5	3.4	3.4	3.5	2		
3	3.0	2.4	2.0	1.6	1.3	1.1	1.0	1.0	1.1	1.3	1.7	2.2	2.8	3.6	4.2	4.1	3.9	3.7	3.5	3.4	3.3	3.2	3.2	3.1	3.1	3.0	3.0	2.9	2.9	3.0	3		
4	2.2	1.6	1.2	0.8	0.5	0.3	0.2	0.2	0.3	0.5	0.9	1.4	2.0	2.8	3.4	3.3	3.1	2.9	2.7	2.6	2.5	2.4	2.4	2.3	2.3	2.2	2.2	2.1	2.1	2.2	4		
5	1.7	1.1	0.7	0.3	0.0	—	—	—	—	—	0.3	0.4	0.9	1.5	2.0	2.3	2.9	2.8	2.6	2.4	2.2	2.1	2.0	1.9	1.8	1.8	1.7	1.7	1.6	1.6	1.7	5	
6	1.8	1.2	0.8	0.4	0.1	—	—	—	—	—	0.1	0.5	1.0	1.6	2.4	3.0	2.9	2.7	2.5	2.3	2.2	2.1	2.0	2.0	1.9	1.9	1.8	1.8	1.7	1.7	1.8	6	
7	2.3	1.7	1.3	0.9	0.6	0.4	0.3	0.3	0.4	0.6	1.0	1.5	2.1	2.9	3.5	3.4	3.2	3.0	2.8	2.7	2.6	2.5	2.5	2.4	2.4	2.3	2.3	2.2	2.2	2.3	7		
8	2.9	2.3	1.9	1.5	1.2	1.0	0.9	0.9	1.0	1.2	1.6	2.1	2.7	3.5	4.1	4.0	3.8	3.6	3.4	3.3	3.2	3.1	3.1	3.0	3.0	2.9	2.9	2.8	2.8	2.9	8		
9	3.7	3.1	2.7	2.3	2.0	1.8	1.7	1.7	1.8	2.0	2.4	2.9	3.5	4.3	4.9	4.8	4.6	4.4	4.2	4.1	4.0	3.9	3.9	3.8	3.8	3.7	3.7	3.6	3.6	3.7	9		
10	4.2	3.6	3.2	2.8	2.5	2.3	2.2	2.2	2.3	2.5	2.9	3.4	4.0	4.8	5.4	5.3	5.1	4.9	4.7	4.6	4.5	4.4	4.4	4.3	4.3	4.2	4.2	4.1	4.1	4.2	10		
11	4.3	3.7	3.3	2.9	2.6	2.4	2.3	2.3	2.4	2.6	3.0	3.5	4.1	4.9	5.5	5.4	5.2	5.0	4.8	4.7	4.6	4.5	4.5	4.4	4.4	4.3	4.3	4.2	4.2	4.3	11		
From a to b. Diagram I																From b to c. Diagram I																	
From c to d. Diagram II																From d to e. Diagram II																	

TABLE IX.—SAN DIEGO—Continued.

Time of moon's transit.	LARGE EBB TIDE, OR FROM LARGE HIGH WATER TO LARGE LOW WATER.																FROM LARGE LOW WATER TO SMALL HIGH WATER.																Time of moon's transit.
	Days from moon's greatest declination.																Days from moon's greatest declination.																
	Before—								After—								Before—								After—								
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7			
H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	H.			
0	5.2	5.8	6.2	6.6	6.9	7.1	7.2	7.2	7.1	6.9	6.5	6.0	5.4	4.6	4.0	4.1	4.3	4.5	4.7	4.8	4.9	5.0	5.0	5.1	5.1	5.2	5.2	5.3	5.3	5.2	0		
1	5.0	5.6	6.0	6.4	6.7	6.9	7.0	7.0	6.9	6.7	6.3	5.8	5.2	4.4	3.8	3.9	4.1	4.3	4.5	4.6	4.7	4.8	4.8	4.9	4.9	5.0	5.0	5.1	5.1	5.0	1		
2	4.7	5.3	5.7	6.1	6.4	6.6	6.7	6.7	6.6	6.4	6.0	5.5	4.9	4.1	3.5	3.6	3.8	4.0	4.2	4.3	4.4	4.5	4.5	4.6	4.6	4.7	4.7	4.8	4.8	4.7	2		
3	4.2	4.8	5.2	5.6	5.9	6.1	6.2	6.2	6.1	5.9	5.5	5.0	4.4	3.6	3.0	3.1	3.3	3.5	3.7	3.8	3.9	4.0	4.0	4.1	4.1	4.2	4.2	4.3	4.3	4.2	3		
4	3.4	4.0	4.4	4.8	5.1	5.3	5.4	5.4	5.3	5.1	4.7	4.2	3.6	2.8	2.2	2.3	2.5	2.7	2.9	3.0	3.1	3.2	3.2	3.3	3.3	3.4	3.4	3.5	3.5	3.4	4		
5	2.9	3.5	3.9	4.3	4.6	4.8	4.9	4.9	4.8	4.6	4.2	3.7	3.1	2.3	1.7	1.8	2.0	2.2	2.4	2.5	2.6	2.7	2.7	2.8	2.8	2.9	2.9	3.0	3.0	2.9	5		
6	3.0	3.6	4.0	4.4	4.7	4.9	5.0	5.0	4.9	4.7	4.3	3.8	3.2	2.4	1.8	1.9	2.1	2.3	2.5	2.6	2.7	2.8	2.8	2.9	2.9	3.0	3.0	3.1	3.1	3.0	6		
7	3.5	4.1	4.5	4.9	5.2	5.4	5.5	5.5	5.4	5.2	4.8	4.3	3.7	2.9	2.3	2.4	2.6	2.8	3.0	3.1	3.2	3.3	3.3	3.4	3.4	3.5	3.5	3.6	3.6	3.5	7		
8	4.1	4.7	5.1	5.5	5.8	6.0	6.1	6.1	6.0	5.8	5.4	4.9	4.3	3.5	2.9	3.0	3.2	3.4	3.6	3.7	3.8	3.9	3.9	4.0	4.0	4.1	4.1	4.2	4.2	4.1	8		
9	4.9	5.5	5.9	6.3	6.6	6.8	6.9	6.9	6.8	6.6	6.2	5.7	5.1	4.3	3.7	3.8	4.0	4.2	4.4	4.5	4.6	4.7	4.7	4.8	4.8	4.9	4.9	5.0	5.0	4.9	9		
10	5.4	6.0	6.4	6.8	7.1	7.3	7.4	7.4	7.3	7.1	6.7	6.2	5.6	4.8	4.2	4.3	4.5	4.7	4.9	5.0	5.1	5.2	5.2	5.3	5.3	5.4	5.4	5.5	5.5	5.4	10		
11	5.5	6.1	6.5	6.9	7.2	7.4	7.5	7.5	7.4	7.2	6.8	6.3	5.7	4.9	4.3	4.4	4.6	4.8	5.0	5.1	5.2	5.3	5.3	5.4	5.4	5.5	5.5	5.6	5.6	5.5	11		
From c to d.....Diagram I																From d to e.....Diagram I																	
From a to b.....Diagram II																From b to c.....Diagram II																	

TABLE IX.—SAN FRANCISCO.

Time of moon's transit.	SMALL EBB TIDE, OR FROM SMALL HIGH WATER TO SMALL LOW WATER.														FROM SMALL LOW WATER TO LARGE HIGH WATER.														Time of moon's transit.		
	Days from moon's greatest declination.														Days from moon's greatest declination.																
	Before—							After—							Before—							After—									
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5		6	7
	H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.		Ft.	Ft.	H.
0	4.7	4.0	3.4	2.9	2.4	2.0	1.8	1.7	1.7	1.9	2.2	2.6	3.1	3.7	4.4	5.2	4.9	4.6	4.5	4.0	3.7	3.4	3.2	3.1	3.0	3.1	3.1	3.3	3.4	3.5	0
1	4.5	3.8	3.2	2.7	2.2	1.8	1.6	1.5	1.5	1.7	2.0	2.4	2.9	3.5	4.2	5.0	4.7	4.4	4.3	3.8	3.5	3.2	3.0	2.9	2.8	2.9	2.9	3.1	3.2	3.3	1
2	4.3	3.6	3.0	2.5	2.0	1.6	1.4	1.3	1.3	1.5	1.8	2.2	2.7	3.3	4.0	4.8	4.5	4.2	4.1	3.6	3.3	3.0	2.8	2.7	2.6	2.7	2.7	2.9	3.0	3.1	2
3	4.0	3.3	2.7	2.2	1.7	1.3	1.1	1.0	1.0	1.2	1.5	1.9	2.4	3.0	3.7	4.5	4.2	3.9	3.8	3.3	3.0	2.7	2.5	2.4	2.3	2.4	2.4	2.6	2.7	2.8	3
4	3.6	2.9	2.3	1.8	1.3	0.9	0.7	0.6	0.6	0.8	1.1	1.5	2.0	2.6	3.3	4.1	3.8	3.5	3.4	2.9	2.6	2.3	2.1	2.0	1.9	2.0	2.0	2.2	2.3	2.4	4
5	3.2	2.5	1.9	1.4	0.9	0.5	0.3	0.2	0.2	0.4	0.7	1.1	1.6	2.2	2.9	3.7	3.4	3.1	3.0	2.5	2.2	1.9	1.7	1.6	1.5	1.6	1.6	1.8	1.9	2.0	5
6	3.2	2.5	1.9	1.4	0.9	0.5	0.3	0.2	0.2	0.4	0.7	1.1	1.6	2.2	2.9	3.7	3.4	3.1	3.0	2.5	2.2	1.9	1.7	1.6	1.5	1.6	1.6	1.8	1.9	2.0	6
7	3.4	2.7	2.1	1.6	1.1	0.7	0.5	0.4	0.4	0.6	0.9	1.3	1.8	2.4	3.1	3.9	3.6	3.3	3.2	2.7	2.4	2.1	1.9	1.8	1.7	1.8	1.8	2.0	2.1	2.2	7
8	3.8	3.1	2.5	2.0	1.5	1.1	0.9	0.8	0.8	1.0	1.3	1.7	2.2	2.8	3.5	4.3	4.0	3.7	3.6	3.1	2.8	2.5	2.3	2.2	2.1	2.2	2.2	2.4	2.5	2.6	8
9	4.1	3.4	2.8	2.3	1.8	1.4	1.2	1.1	1.1	1.3	1.6	2.0	2.5	3.1	3.8	4.6	4.3	4.0	3.9	3.4	3.1	2.8	2.6	2.5	2.4	2.5	2.5	2.7	2.8	2.9	9
10	4.5	3.8	3.2	2.7	2.2	1.8	1.6	1.5	1.5	1.7	2.0	2.4	2.9	3.5	4.2	5.0	4.7	4.4	4.3	3.8	3.5	3.2	3.0	2.9	2.8	2.9	2.9	3.1	3.2	3.3	10
11	4.7	4.0	3.4	2.9	2.4	2.0	1.8	1.7	1.7	1.9	2.2	2.6	3.1	3.7	4.4	5.2	4.9	4.6	4.5	4.0	3.7	3.4	3.2	3.1	3.0	3.1	3.1	3.3	3.4	3.5	11
From a to b.....Diagram I															From b to c.....Diagram I																
From c to d.....Diagram II															From d to e.....Diagram II																

TABLE IX.—SAN FRANCISCO—Continued.

Time of moon's transit.	LARGE EBB TIDE, OR FROM LARGE HIGH WATER TO LARGE LOW WATER.															FROM LARGE LOW WATER TO SMALL HIGH WATER.															Time of moon's transit.
	Days from moon's greatest declination.															Days from moon's greatest declination.															
	Before—							After—								Before—							After—								
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
	H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	
0	3.9	4.6	5.2	5.7	6.2	6.6	6.8	6.9	6.9	6.7	6.4	6.0	5.5	4.9	4.2	3.4	3.7	4.0	4.1	4.6	4.9	5.2	5.4	5.5	5.6	5.6	5.5	5.3	5.2	5.2	H.
1	3.7	4.4	5.0	5.5	6.0	6.4	6.6	6.7	6.7	6.5	6.2	5.8	5.3	4.7	4.0	3.2	3.5	3.8	3.9	4.4	4.7	5.0	5.2	5.3	5.4	5.5	5.3	5.1	5.0	5.0	0
2	3.5	4.2	4.8	5.3	5.8	6.2	6.4	6.5	6.5	6.3	6.0	5.6	5.1	4.5	3.8	3.0	3.3	3.6	3.7	4.2	4.5	4.8	5.0	5.1	5.2	5.1	5.1	4.9	4.8	4.8	1
3	3.2	3.9	4.5	5.0	5.5	5.9	6.1	6.2	6.2	6.0	5.7	5.3	4.8	4.2	3.5	2.7	3.0	3.3	3.4	3.9	4.2	4.5	4.7	4.8	4.9	4.8	4.8	4.6	4.5	4.5	2
4	2.8	3.5	4.1	4.6	5.1	5.5	5.7	5.8	5.8	5.6	5.3	4.9	4.4	3.8	3.1	2.3	2.6	2.9	3.0	3.5	3.8	4.1	4.3	4.4	4.5	4.4	4.4	4.2	4.1	4.1	3
5	2.4	3.1	3.7	4.2	4.7	5.1	5.3	5.4	5.4	5.2	4.9	4.5	4.0	3.4	2.7	1.9	2.2	2.5	2.6	3.1	3.4	3.7	3.9	4.0	4.1	4.0	4.0	3.8	3.7	3.7	4
6	2.4	3.1	3.7	4.2	4.7	5.1	5.3	5.4	5.4	5.2	4.9	4.5	4.0	3.4	2.7	1.9	2.2	2.5	2.6	3.1	3.4	3.7	3.9	4.0	4.1	4.0	4.0	3.8	3.7	3.7	5
7	2.6	3.3	3.9	4.4	4.9	5.3	5.5	5.6	5.6	5.4	5.1	4.7	4.2	3.6	2.9	2.1	2.4	2.7	2.8	3.3	3.6	3.9	4.1	4.2	4.3	4.2	4.2	4.0	3.9	3.9	6
8	3.0	3.7	4.3	4.8	5.3	5.7	5.9	6.0	6.0	5.8	5.5	5.1	4.6	4.0	3.3	2.5	2.8	3.1	3.2	3.7	4.0	4.3	4.5	4.6	4.7	4.6	4.6	4.4	4.3	4.3	7
9	3.3	4.0	4.6	5.1	5.6	6.0	6.2	6.3	6.3	6.1	5.8	5.4	4.9	4.3	3.6	2.8	3.1	3.4	3.5	4.0	4.3	4.6	4.8	4.9	5.0	4.9	4.9	4.7	4.6	4.6	8
10	3.7	4.4	5.0	5.5	6.0	6.4	6.6	6.7	6.7	6.5	6.2	5.8	5.3	4.7	4.0	3.2	3.5	3.8	3.9	4.4	4.7	5.0	5.2	5.3	5.4	5.3	5.3	5.1	5.0	5.0	10
11	3.9	4.6	5.2	5.7	6.2	6.6	6.8	6.9	6.9	6.7	6.4	6.0	5.5	4.9	4.2	3.4	3.7	4.0	4.0	4.6	4.9	5.2	5.4	5.5	5.6	5.5	5.5	5.3	5.2	5.2	11
From c to d.....Diagram I															From d to e.....Diagram I																
From a to c.....Diagram II															From b to c.....Diagram II																

REPORT OF THE SUPERINTENDENT OF

TABLE IX.—ASTORIA.

HOURS of moon's transit.	SMALL EBB TIDE, OR FROM SMALL HIGH WATER TO SMALL LOW WATER.																FROM SMALL LOW WATER TO LARGE HIGH WATER.																HOURS of moon's transit.
	Days from moon's greatest declination.																Days from moon's greatest declination.																
	Before—								After—								Before—								After—								
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7			
H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	H.			
0	7.4	6.7	6.0	5.4	5.0	4.6	4.5	4.5	4.6	4.7	5.1	5.5	6.2	6.9	7.8	8.0	7.8	7.5	7.2	6.8	6.4	6.3	6.2	6.1	6.2	6.2	6.3	6.3	6.3	6.4	0		
1	7.5	6.8	6.1	5.5	5.1	4.7	4.6	4.6	4.7	4.8	5.2	5.6	6.3	7.0	7.9	8.1	7.9	7.6	7.3	6.9	6.5	6.4	6.3	6.2	6.3	6.3	6.4	6.4	6.4	6.5	1		
2	7.2	6.5	5.8	5.2	4.8	4.4	4.3	4.3	4.4	4.5	4.9	5.3	6.0	6.7	7.6	7.8	7.6	7.3	7.0	6.6	6.2	6.1	6.0	5.9	6.0	6.0	6.1	6.1	6.1	6.2	2		
3	6.6	5.9	5.2	4.6	4.2	3.8	3.7	3.7	3.8	3.9	4.3	4.7	5.4	6.1	7.0	7.2	7.0	6.7	6.4	6.0	5.6	5.5	5.4	5.3	5.4	5.4	5.5	5.5	5.5	5.6	3		
4	5.9	5.2	4.5	3.9	3.5	3.1	3.0	3.0	3.1	3.2	3.6	4.0	4.7	5.4	6.3	6.5	6.3	6.0	5.7	5.3	4.9	4.8	4.7	4.6	4.7	4.7	4.8	4.8	4.8	4.9	4		
5	5.2	4.5	3.8	3.2	2.8	2.4	2.3	2.3	2.4	2.5	2.9	3.3	4.0	4.7	5.6	5.8	5.6	5.3	5.0	4.6	4.2	4.1	4.0	3.9	4.0	4.0	4.1	4.1	4.1	4.2	5		
6	4.8	4.1	3.4	2.8	2.4	2.0	1.9	1.9	2.0	2.1	2.5	2.9	3.6	4.3	5.2	5.4	5.2	4.9	4.6	4.2	3.8	3.7	3.6	3.5	3.6	3.6	3.7	3.7	3.7	3.8	6		
7	5.0	4.3	3.6	3.0	2.6	2.2	2.1	2.1	2.2	2.3	2.7	2.1	3.8	4.5	5.4	5.6	5.4	5.1	4.8	4.4	4.0	3.9	3.8	3.7	3.8	3.8	3.9	3.9	3.9	4.0	7		
8	5.5	4.8	4.1	3.5	3.1	2.7	2.6	2.6	2.7	2.8	3.2	3.6	4.3	5.0	5.9	6.1	5.9	5.6	5.3	4.9	4.5	4.4	4.3	4.2	4.3	4.3	4.4	4.4	4.4	4.5	8		
9	6.3	5.6	4.9	4.3	3.9	3.5	3.4	3.4	3.5	3.6	4.0	4.4	5.1	5.8	6.7	6.9	6.7	6.4	6.1	5.7	5.3	5.2	5.1	5.0	5.1	5.1	5.2	5.2	5.2	5.3	9		
10	7.0	6.3	5.6	5.0	4.6	4.2	4.1	4.1	4.2	4.3	4.7	5.1	5.8	6.5	7.4	7.6	7.4	7.1	6.8	6.4	6.0	5.9	5.8	5.7	5.8	5.8	5.9	5.9	5.9	6.0	10		
11	7.3	6.6	6.9	5.3	4.9	4.5	4.4	4.4	4.5	4.6	5.0	5.4	6.1	6.8	7.7	7.9	7.7	7.4	7.1	6.7	6.3	6.2	6.1	6.0	6.1	6.1	6.2	6.2	6.2	6.3	11		
From <i>a</i> to <i>b</i>																	Diagram I																
From <i>c</i> to <i>d</i>																	Diagram II																

TABLE IX.—ASTORIA—Continued.

Hours of moon's transit.	LARGE FBB TIDE, OR FROM LARGE HIGH WATER TO LARGE LOW WATER.																FROM LARGE LOW WATER TO SMALL HIGH WATER.																Hours of moon's transit.
	Days from moon's greatest declination.																Days from moon's greatest declination.																
	Before—								After—								Before—								After—								
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7			
	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>	<i>Ft.</i>			
<i>H.</i>	7.0	7.7	8.4	9.0	9.4	9.8	9.9	9.9	9.8	9.7	9.3	8.9	8.2	7.5	6.6	6.4	6.6	6.9	7.2	7.6	8.0	8.1	8.2	8.3	8.2	8.2	8.1	8.1	8.1	8.0			
0	7.1	7.8	8.5	9.1	9.5	9.9	10.0	10.0	9.9	9.8	9.4	9.0	8.3	7.6	6.7	6.5	6.7	7.0	7.3	7.7	8.1	8.2	8.3	8.4	8.3	8.3	8.2	8.2	8.2	8.1			
1	6.8	7.5	8.2	8.8	9.2	9.6	9.7	9.7	9.6	9.5	9.1	8.7	8.0	7.3	6.4	6.2	6.4	6.7	7.0	7.4	7.8	7.9	8.0	8.1	8.0	8.0	7.9	7.9	7.8	7.8			
2	6.2	6.9	7.6	8.2	8.6	9.0	9.1	9.1	9.0	8.9	8.5	8.1	7.4	6.7	5.8	5.6	5.8	6.1	6.4	6.8	7.2	7.3	7.4	7.5	7.4	7.4	7.3	7.3	7.3	7.2			
3	5.5	6.2	6.9	7.5	7.9	8.3	8.4	8.4	8.3	8.2	7.8	7.4	6.7	6.0	5.1	4.9	5.1	5.4	5.7	6.1	6.5	6.6	6.7	6.8	6.7	6.7	6.6	6.6	6.6	6.5			
4	4.8	5.5	6.2	6.8	7.2	7.6	7.7	7.7	7.6	7.5	7.1	6.7	6.0	5.3	4.4	4.2	4.4	4.7	5.0	5.4	5.8	5.9	6.0	6.1	6.0	6.0	5.9	5.9	5.9	5.8			
5	4.4	5.1	5.8	6.4	6.8	7.2	7.3	7.3	7.2	7.1	6.7	6.3	5.6	4.9	4.0	3.8	4.0	4.3	4.6	5.0	5.4	5.5	5.6	5.7	5.6	5.6	5.5	5.5	5.5	5.4			
6	4.6	5.3	6.0	6.6	7.0	7.4	7.5	7.5	7.4	7.3	6.9	6.5	5.8	5.1	4.2	4.0	4.2	4.5	4.8	5.2	5.6	5.7	5.8	5.9	5.8	5.8	5.7	5.7	5.7	5.6			
7	5.1	5.8	6.5	7.1	7.5	7.9	8.0	8.0	7.9	7.8	7.4	7.0	6.3	5.6	4.7	4.5	4.7	5.0	5.3	5.7	6.1	6.2	6.3	6.4	6.3	6.3	6.2	6.2	6.2	6.1			
8	5.9	6.6	7.3	7.9	8.3	8.7	8.8	8.8	8.7	8.6	8.2	7.8	7.1	6.4	5.5	5.3	5.5	5.8	6.1	6.5	6.9	7.0	7.1	7.2	7.1	7.1	7.0	7.0	7.0	6.9			
9	6.6	7.3	8.0	8.6	9.0	9.4	9.5	9.5	9.4	9.3	8.9	8.5	7.8	7.1	6.2	6.0	6.2	6.5	6.8	7.2	7.6	7.7	7.8	7.9	7.8	7.8	7.7	7.7	7.7	7.6			
10	6.9	7.6	8.3	8.9	9.3	9.7	9.8	9.8	9.7	9.6	9.2	8.8	8.1	7.4	7.5	6.3	6.5	6.8	7.1	7.5	7.9	8.0	8.1	8.2	8.1	8.1	8.0	8.0	8.0	7.9			
From c to d.....Diagram I																From d to c.....Diagram I																	
From a to b.....Diagram II																From b to c.....Diagram II																	

TABLE IX.—PORT TOWNSHEND.

Hours of moon's transit.	SMALL EBB TIDE, OR FROM SMALL HIGH WATER TO SMALL LOW WATER.														FROM SMALL LOW WATER TO LARGE HIGH WATER.														Hours of moon's transit.		
	Days from moon's greatest declination.														Days from moon's greatest declination.																
	Before—							After—							Before—							After—									
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5		6	7
	H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.		Ft.	H.
0	4.5	5.6	6.9	8.0	8.6	8.9	8.8	8.8	8.7	8.7	8.5	8.0	7.3	6.6	5.5	3.5	3.9	4.6	6.0	7.2	8.4	9.0	9.5	9.6	9.4	9.2	8.7	8.2	7.9	7.1	0
1	4.5	5.6	6.9	8.0	8.6	8.9	8.8	8.8	8.7	8.7	8.5	8.0	7.3	6.6	5.5	3.5	3.9	4.6	6.0	7.2	8.4	9.0	9.5	9.6	9.4	9.2	8.7	8.2	7.9	7.1	1
2	4.4	5.5	6.8	7.9	8.5	8.8	8.7	8.7	8.6	8.6	8.4	7.9	7.2	6.5	5.4	3.4	3.8	4.5	5.9	7.1	8.3	8.9	9.4	9.5	9.3	9.1	8.6	8.1	7.8	7.0	2
3	4.1	5.2	6.5	7.6	8.2	8.5	8.4	8.4	8.3	8.3	8.1	7.6	6.9	6.2	5.1	3.1	3.5	4.2	5.6	6.8	8.0	8.6	9.1	9.2	9.0	8.8	8.3	7.8	7.5	6.7	3
4	3.5	4.6	5.9	7.0	7.6	7.9	7.8	7.8	7.7	7.7	7.5	7.0	6.3	5.6	4.5	2.5	2.9	3.6	5.0	6.2	7.4	8.0	8.5	8.6	8.4	8.2	7.7	7.2	6.9	6.1	4
5	3.1	4.2	5.5	6.6	7.2	7.5	7.4	7.4	7.3	7.3	7.1	6.6	5.9	5.2	4.1	2.1	2.5	3.2	4.6	5.8	7.0	7.6	8.1	8.2	8.0	7.8	7.3	6.8	6.5	5.7	5
6	3.1	4.2	5.5	6.6	7.2	7.5	7.4	7.4	7.3	7.3	7.1	6.6	5.9	5.2	4.1	2.1	2.5	3.2	4.6	5.8	7.0	7.6	8.1	8.2	8.0	7.8	7.3	6.8	6.5	5.7	6
7	3.3	4.4	5.7	6.8	7.4	7.7	7.6	7.6	7.5	7.5	7.3	6.8	6.1	5.4	4.3	2.3	2.7	3.4	4.8	6.0	7.2	7.8	8.3	8.4	8.2	8.0	7.5	7.0	6.7	5.9	7
8	3.5	4.6	5.9	7.0	7.6	7.9	7.8	7.8	7.7	7.7	7.5	7.0	6.3	5.6	4.5	2.5	2.9	3.6	5.0	6.2	7.4	8.0	8.5	8.6	8.4	8.2	7.7	7.2	6.9	6.1	8
9	3.7	4.8	6.1	7.2	7.8	8.1	8.0	8.0	7.9	7.9	7.7	7.2	6.5	5.8	4.7	2.7	3.1	3.8	5.2	6.4	7.6	8.2	8.7	8.8	8.6	8.4	7.9	7.4	7.1	6.3	9
10	4.1	5.2	6.5	7.6	8.2	8.5	8.4	8.4	8.3	8.3	8.1	7.6	6.9	6.2	5.1	3.1	3.5	4.2	5.6	6.8	8.0	8.6	9.1	9.2	9.0	8.8	8.3	7.8	7.5	6.7	10
11	4.4	5.5	6.8	7.9	8.5	8.8	8.7	8.7	8.6	8.6	8.4	7.9	7.2	6.5	5.4	3.4	3.8	4.5	5.9	7.1	8.3	8.9	9.4	9.5	9.3	9.1	8.6	8.1	7.8	7.0	11

TABLE IX.—FORT TOWNSHEND—Continued.

Hours of moon's transit.	LARGE EBB TIDE, OR FROM LARGE HIGH WATER TO LARGE LOW WATER.																FROM SMALL LOW WATER TO LARGE HIGH WATER.																Hours of moon's transit.
	Days from moon's greatest declination.																Days from moon's greatest declination.																
	Before—								After—								Before—								After—								
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7			
	H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	H.		
0	6.5	5.4	4.1	3.0	2.4	2.1	2.2	2.2	2.3	2.3	2.5	3.0	3.7	4.4	5.5	7.5	7.1	6.4	5.0	3.8	2.6	2.0	1.5	1.4	1.6	1.8	2.3	2.8	3.1	3.9	0		
1	6.5	5.4	4.1	3.0	2.4	2.1	2.2	2.2	2.3	2.3	2.5	3.0	3.7	4.4	5.5	7.5	7.1	6.4	5.0	3.8	2.6	2.0	1.5	1.4	1.6	1.8	2.3	2.8	3.1	3.9	1		
2	6.4	5.3	4.0	2.9	2.3	2.0	2.1	2.1	2.2	2.2	2.4	2.9	3.6	4.3	5.4	7.4	7.0	6.3	4.9	3.7	2.5	1.9	1.4	1.3	1.5	1.7	2.2	2.7	3.0	3.8	2		
3	6.1	5.0	3.7	2.6	2.0	1.7	1.8	1.8	1.9	1.9	2.1	2.6	3.3	4.0	5.1	7.1	6.7	6.0	4.6	3.4	2.2	1.6	1.1	1.0	1.2	1.4	1.9	2.4	2.7	3.5	3		
4	5.5	4.4	3.1	2.0	1.4	1.1	1.2	1.2	1.3	1.3	1.5	2.0	2.7	3.4	4.5	6.5	6.1	5.4	4.0	2.8	1.6	1.0	0.5	0.4	0.6	0.8	1.3	1.8	2.1	2.9	4		
5	5.1	4.0	2.7	1.6	1.0	0.7	0.8	0.8	0.9	0.9	1.1	1.6	2.3	3.0	4.1	6.1	5.7	5.0	3.6	2.4	1.2	0.6	0.1	0.0	0.2	0.4	0.9	1.4	1.7	2.5	5		
6	5.1	4.0	2.7	1.6	1.0	0.7	0.8	0.8	0.9	0.9	1.1	1.6	2.3	3.0	4.1	6.1	5.7	5.0	3.6	2.4	1.2	0.6	0.1	0.0	0.2	0.4	0.9	1.4	1.7	2.5	6		
7	5.3	4.2	2.9	1.8	1.2	0.9	1.0	1.0	1.1	1.1	1.3	1.8	2.5	3.2	4.3	6.3	5.9	5.2	3.8	2.6	1.4	0.8	0.3	0.2	0.4	0.6	1.1	1.6	1.9	2.7	7		
8	5.5	4.4	3.1	2.0	1.4	1.1	1.2	1.2	1.3	1.3	1.5	2.0	2.7	3.4	4.5	6.5	6.1	5.4	4.0	2.8	1.6	1.0	0.5	0.4	0.6	0.8	1.3	1.8	2.1	2.9	8		
9	5.7	4.6	3.3	2.2	1.6	1.3	1.4	1.4	1.5	1.5	1.7	2.2	2.9	3.6	4.7	6.7	6.3	5.6	4.2	3.0	1.8	1.2	0.7	0.6	0.8	1.0	1.5	2.0	2.3	3.1	9		
10	6.1	5.0	3.7	2.6	2.0	1.7	1.8	1.8	1.9	1.9	2.1	2.6	3.3	4.0	5.1	7.1	6.7	6.0	4.6	3.4	2.2	1.6	1.1	1.0	1.2	1.4	1.9	2.4	2.7	3.5	10		
11	6.4	5.3	4.0	2.9	2.3	2.0	2.1	2.1	2.2	2.2	2.4	2.9	3.6	4.3	5.4	7.4	7.0	6.3	4.9	3.7	2.5	1.9	1.4	1.3	1.5	1.7	2.2	2.7	3.0	3.8	11		

Example VII.—Thus, in *Example VI*, the high water of February 7 was found to be 3.3 feet above mean low water. The declination being south, diagram I applies, and this high water is the small one. To obtain the fall of the next low water, or small low water, we enter Table IX, for San Francisco, with 0% of moon's transit, and two days after the greatest declination in the first part of the table, and find 1.9 foot, which will be the difference in the height of this high and low water. Entering with the same transit and day in the second part, we find 3.0 feet, which is the rise of the large high above the small low water; the difference between 1.9 and 3.0, or 1.1 foot, is the difference of height of the two successive high waters.

It is easy to see how, in this way, the soundings of a chart can be reduced to what they would be approximately at all the successive high and low waters.

TIDES OF THE GULF OF MEXICO.

On the coast of Florida, from Cape Florida around the peninsula to St. Mark's, the tides are of the ordinary kind, but with a daily inequality which, small at Cape Florida, goes on increasing as we proceed westward to Tortugas. From the Tortugas to St. Mark's the daily inequality is large and sensibly the same,

giving the tides a great resemblance to those of the Pacific coast, though the rise and fall is much smaller. Between St. Mark's and St George's island, Apalachicola entrance, the tides change to the single-day class, ebbing and flowing but once in the twenty-four (lunar) hours.

At St. George's island there are two tides a day, for three or four days, about the time of the moon's declination being zero. At other times there is but one tide a day, with a long stand at high water of from six to nine hours. From Cape St. Blas to and including the mouth of the Mississippi, the single-day tides are very regular, and the small and irregular double tides appear only for two or three days, (and frequently even not at all,) about the time of zero declination of the moon. The stand at high and low water is comparatively short, seldom exceeding an hour.

To the west of the mouth of the Mississippi the double tides reappear. At Isle Dernière they are distinct, though a little irregular for three or four days near the time of the moon's zero declination. At all other times the single-day type prevails, the double tides modifying it, however, in the shape of a long stand of from six to ten hours at high water. This stand is shortest at the time of the moon's greatest declination, sometimes being reduced to but one hour. At Calcasieu the tides are distinctly double, but with a large daily inequality. The rise and fall being small, they would often present to the ordinary observer the same appearance as at Isle Dernière. At Galveston the double tides are plainly perceptible, though small, for five or six days at the time of the moon's zero declination. At other times they present the single-day type, with the peculiarity that, after standing at high water for a short time, the water falls a small distance, and stands again at that height for several hours, then continues to fall to low water. Sometimes it falls very slowly for nine or ten hours following high water, and then acquires a more rapid rate to low water. At Aransas Pass and Brazos Santiago the single-day tides prevail. Small, irregular, double tides are only perceived for two or three days at the moon's zero declination. At all other times there is but one high water in the day, with a long stand of from six to nine hours, during which there are often small, irregular fluctuations or a very slow fall. In the following table the mean rise and fall of tides at the above stations are given.

The highest high and the lowest low water occur when the greatest declination of the moon happens at full or change; the least tide when the moon's declination is nothing at the first or last quarter. The rise and fall being so small, the times and heights are both much influenced by the winds, and are thus rendered quite irregular.

TABLE X.

Rise and fall at several stations on the Gulf of Mexico.

Stations.	Mean rise and fall of tides.		
	Mean.	At moon's greatest declination.	At moon's least declination.
	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>
St. George's island, Florida	1.1	1.8	0.6
Pensacola, Florida	1.0	1.5	0.4
Fort Morgan, Mobile bay, Alabama.....	1.0	1.5	0.4
Cat island, Mississippi.....	1.3	1.9	0.6
Southwest Pass, Louisiana.....	1.1	1.4	0.5
Isle Dernière, Louisiana	1.4	2.2	0.7
Entrance to Lake Calcasieu, Louisiana	1.9	2.4	1.7
Galveston, Texas	1.1	1.6	0.8
Aransas Pass, Texas	1.1	1.8	0.6
Brazos Santiago, Texas.....	0.9	1.2	0.5

TO DETERMINE THE RISE AND FALL OF THE TIDES FOR ANY GIVEN TIME FROM HIGH OR LOW WATER.

It is sometimes desirable to know how far the tide will rise in a given time from low water, or fall in a given time from high water, or to approximate to the time which has elapsed from low or high water, by knowing the rise and fall of the tide in the interval. If the proportion of the rise and fall in a given time were the same in the different ports, this would easily be shown in a single table, giving the proportional rise and fall, which, by referring to Table I, showing the rise and fall of the tide at the port, would give the rise and fall in feet and decimals. The proportion, however, is not the same in different ports, nor in the same ports for tides of different heights. The following Table XI shows the relation between the heights above low water for each half hour for New York and Old Point Comfort, and for spring and neap tides at each place. Units express the total rise of high water above low water, and the figures opposite to each half hour denote the proportional fall of the tide from high water onward to low water. For example, at New York, three hours after high water, a spring tide has fallen six-tenths (sixty-hundredths) of the whole fall. Suppose the whole rise and fall of that day to be 5.4 feet, (Table I,) then three hours after high water the tide will have fallen 3.24 feet, or three feet three inches nearly. Conversely, if we have observed that a spring tide has fallen three feet three inches, we may know that high water has passed about three hours.

TABLE XI.

Giving the height of the tide above low water for every half hour before or after high water, the total range being taken as equal to 1.

Time before or after high water.	New York.		Old Point Comfort.	
	Spring tide.	Neap tide.	Spring tide.	Neap tide.
<i>h. m.</i>				
0 0	1.00	1.00	1.00	1.00
0 30	0.98	0.98	0.98	0.98
1 0	0.94	0.93	0.95	0.94
1 30	0.89	0.86	0.88	0.87
2 0	0.80	0.72	0.80	0.78
2 30	0.72	0.59	0.70	0.68
3 0	0.60	0.45	0.59	0.57
3 30	0.49	0.31	0.49	0.44
4 0	0.39	0.19	0.37	0.34
4 30	0.28	0.10	0.26	0.22
5 0	0.18	0.02	0.17	0.13
5 30	0.09	0.00	0.08	0.05
6 0	0.05	-----	0.03	0.01
6 30	0.00	-----	0.00	0.00

TIDES IN COASTING.

By observing the time of high water and low water along the coast we find the places at which they are the same. The map of co-tidal lines (Sketch No. 65, C. S. Rep., 1857) shows that it is high water nearly at the same hour all along the coast from Sandy Hook to Cape Cañaveral; of course not in bays and harbors and up the rivers, but on the outer coast.

It is high water exactly at the same hour all along the line marked XII, seen on the chart, near Sandy Hook, and north and south of Hatteras, and with small interruptions at Cape Lookout and Cape Fear, all the way to near Cape Cañaveral. The same line extends eastward to near Block island, and south of Nantucket, and then passes away from our coast. At full and change of the moon, along this line, (approximately,) it is high water at twelve o'clock, Greenwich time, the local time of high water depending upon the longitude of

the place; or, to speak more correctly, in the average of a lunar month it is high water so many hours after the time of the moon's passing the meridian of Greenwich. By these lines, called co-tidal lines, we can determine what tidal currents the navigators must expect to meet in coasting; and for this purpose we divide the ports of the coast into two sets, those south and those north of New York.

The sailing lines of coasters, bound to southern ports this side of the straits of Florida, are marked upon the map, and also those bound through the sounds to eastern ports, and outside to Halifax and European ports.

VESSELS TO AND FROM PORTS SOUTH OF NEW YORK.

South of Sandy Hook, New Jersey, the line of XII hours is nowhere more than 18 miles from the coast; that of $XI\frac{1}{2}$ nowhere more than 35 miles; that of $XI\frac{1}{4}$ nowhere more than 48; and XI nowhere more than 110. The distance of these lines of XII to XI hours, (corresponding within four minutes to VII and VI of New York time,) for different parts of the coast, is shown from Table A, where the first column gives the name of the place, and the second, third, fourth, fifth, respectively, the distances of the co-tidal lines of XII, $XI\frac{1}{2}$, $XI\frac{1}{4}$, and XI hours. The distances are measured from the ports on perpendiculars to the co-tidal lines. They may be taken as if measured on the parallel of latitude at all the points for the line of XII hours, and at all between Sandy Hook and Cape Hatteras for the lines of $XI\frac{1}{2}$ and $XI\frac{1}{4}$ hours.

A.

Names of locations.	Distance from coast, measured on perpendicular to co-tidal lines.			
	At XII hours.	At $XI\frac{1}{4}$ hours.	At $XI\frac{1}{2}$ hours.	At XI hours.
	<i>Nautical miles.</i>	<i>Nautical miles.</i>	<i>Nautical miles.</i>	<i>Nautical miles.</i>
Sandy Hook.....	12	32	53	100
Barnegat.....	2	29	39	78
Cape May.....	15	30	46	92
Cape Henlopen.....	18	33	47	92
Assateague.....	7	22	36	82
Cape Henry.....	12	28	43	100
Cape Hatteras.....		8	20	63
Ocracoke inlet.....		11	26	71
Cape Lookout.....		7	18	56
Beaufort entrance, North Carolina.....	6	15	24	63
Cape Fear.....		6	16	55
Cape Roman.....		10	21	67
Charleston light.....	3	15	27	70
Port Royal entrance.....	5	17	29	78
Tybee entrance.....	6	17	31	82
St. Mary's entrance.....	12	25	40	110
St. John's entrance.....	17	35	48	
Cape Cañaveral.....	16			
Cape Florida.....				

The co-tidal lines are in such directions that at 10, 20, and 30 miles from the coast, between Sandy Hook and the St. John's there is but a variation of seven minutes, and even to Cape Cañaveral only of eight minutes.

Keeping ten miles from the shore the coaster would pass from 12 hours at Sandy Hook to 11 hours 45 minutes at Hatteras, and increase again irregularly to 12 hours 7 minutes at the St. John's, as shown more explicitly in Table B. These three tracks of 10, 20, and 30 miles are inside of the cold wall of the Gulf Stream, and generally in the cold current, except at Cape Cañaveral.

B.

Names of stations.	Co-tidal hour at 10, 20, and 30 nautical miles from the coast, perpendicular to the coast.		
	Ten miles off.	Twenty miles off.	Thirty miles off.
	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>
Sandy Hook.....	12 0	11 52	11 45
Barneгат.....	11 52	11 44	11 35
Cape May.....	12 5	11 53	11 45
Cape Henlopen.....	12 7	11 57	11 48
Assateague.....	12 0	11 48	11 37
Cape Henry.....	12 5	11 48	11 42
Cape Hatteras.....	11 45	11 30	11 22
Ocracoke inlet.....	11 47	11 36	11 25
Cape Lookout.....	11 45	11 30	11 20
Beaufort entrance, North Carolina.....	11 55	11 38	11 25
Cape Fear.....	11 38	11 25	11 18
Cape Roman.....	11 45	11 33	11 24
Charleston light.....	11 52	11 38	11 25
Port Royal entrance.....	11 57	11 45	11 32
Tybee entrance.....	11 55	11 43	11 30
St. Mary's entrance.....	12 8	11 57	11 47
St. John's entrance.....	12 7	11 57	11 50
Cape Cañaveral.....	12 8	-----	-----
Cape Florida.....	13 10	-----	-----

It follows, then, as a general thing, from these two tables, that the coaster, in passing from Sandy Hook to the St. John's, would have the tides the same, within some fifteen minutes, as if he remained at Sandy Hook; so that leaving, for example, at high water, he would, according to the elapsed time, have the ebb and flood alternating every six hours and a quarter, nearly, as if he had remained near Sandy Hook. As the flood tide sets in generally to the northward and on shore, and the ebb to the southward and off shore, he would know by the time that elapsed from his departure and the period of the tide at which he started what tidal current she might expect to meet as he passed along the coast. This of course, is not peculiar to Sandy Hook as a point of departure, but would be true for any of the entrances given in the table, taking care not to mistake the time of tides within for that at the entrance.

By referring to George W. Blunt, esq., I have obtained the tracks of sailing and steam vessels passing from New York to ports to the south of it, as shown by the lines on the chart accompanying this paper. (See Sketch No. 65, C. S. Rep., 1857.) Tracing these on the map of co-tidal lines, I have determined how the navigator would find the tides as he passes from port to port. The results are shown in the annexed table, (C.) in which the port between which and Sandy Hook the mariner passes is at the head of the table, and, at the side, the place off which the co-tidal hours will be found, as stated in the table.

C.

Off—	Co-tidal hours on sailing lines measured on parallels of latitude of places named in the first column, between New York and—							
	Delaware bay.	Chesapeake bay.	Ocracoke inlet.	Cape Fear.	Charleston.	Savannah.	St. John's.	Cape Florida.
	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>
Sandy Hook	12 5	12 5	12 5	12 5	12 5	12 5	12 5	12 5
Barnegat	11 57	11 57	11 57	11 57	11 57	11 57	11 57	11 57
Cape May	12 10	11 52	11 45	11 45	11 45	11 45	11 45	11 45
Cape Henlopen		11 51	11 43	11 43	11 43	11 43	11 43	11 43
Assateague		11 55	11 33	11 33	11 33	11 33	11 33	11 33
Cape Henry		12 13	11 24	11 24	11 24	11 24	11 24	11 24
Cape Hatteras			11 48	11 48	11 48	11 48	11 48	11 48
Ocracoke inlet				11 42	11 42	11 42	11 42	11 42
Cape Lookout				11 39	11 39	11 39	11 39	11 24
Beaufort entrance				11 39	11 39	11 39	11 32	11 24
Cape Fear					11 36	11 36	11 24	11 0
Cape Roman					11 46	11 46	11 19	
Charleston light						11 52	11 18	
Fort Royal entrance						12 3	11 18	
Tybee entrance							11 16	
St. Mary's entrance							11 55	
St. John's entrance							12 10	
Cape Canaveral								
Cape Florida								

Thus from Sandy Hook to Delaware bay, starting with 12 hours 5 minutes, off Barnegat there would be, at the same instant, 11 hours 57 minutes, and off Cape May 12 hours 10 minutes, so that the navigator would have the same succession of tides whether he remained at Sandy Hook or passed onward to Delaware bay, or whether he came from Delaware bay to Sandy Hook. So from Sandy Hook to Charleston he will find, at the same instant, 12 hours 5 minutes at Sandy Hook, 11 hours 57 minutes off Barnegat, 11 hours 45 minutes off Cape May, and so onward upon the parallels of latitude for the several points. *For all practical purposes, then, of coasting, the succession of the tides, and, of course, of the tidal currents of flow and ebb, will be the same as if the navigator remained stationary.* Leaving at low water he will meet the flood for 6 hours 15 minutes, and then the ebb for another 6 hours 15 minutes, and so on. It is the simplest of all rules that has thus come out of this investigation. That remarkable change of the temperature between the waters of the in-shore cold current and the warm waters of the Gulf Stream, occurring in so short a distance that Lieutenant Bache called it the "cold wall," takes place at distances off the coast of from 170 to 29 miles, (see Table D,) between Sandy Hook and Cape Canaveral, measured, from the several points named in the table, at right angles to the direction of the course, or measured along the parallels of latitude of the points, at distances from 195 to 28 miles, between Assateague and Cape Canaveral, (Table D.) The points where the parallels north of Assateague meet this division line have not been accurately determined.

The annexed table shows these distances measured at right angles and on the parallels.

D.

Distance from coast to "cold wall" of Gulf Stream, off—	Measured at right angles to coast.	Measured on parallel of latitude.
	<i>Nautical miles.</i>	<i>Nautical miles.</i>
Sandy Hook.....	170	.....
Barnegat.....	135	.....
Cape May.....	137	.....
Cape Henlopen.....	137	.....
Assateague.....	95	195
Cape Henry.....	92	107
Cape Hatteras.....	30	31
Ocracoke inlet.....	53	52
Cape Lookout.....	53	65
Beaufort entrance.....	62	.....
Cape Fear.....	54	97
Cape Roman.....	57	103
Charleston light.....	61	95
Port Royal entrance.....	79	97
Tybee entrance.....	79	95
St. Mary's.....	90	87
St. John's.....	85	82
Cape Cañaveral.....	29	28
Cape Florida.....	.....	.....

The coasting line of thirty miles keeps inside of the cold wall all the way to Cañaveral, and all the routes traced on the chart from Sandy Hook to southern ports are on the inside of it. The Gulf Stream lines, as drawn on the chart, show how the route to Bermuda and to the Bahamas cuts the alternate bands of warm and cold water of the Gulf Stream.

Vessels to and from ports east of New York.

The plate shows the sailing lines of vessels bound from New York to eastern ports and to Halifax, outside. The annexed table (E) gives the Greenwich time of high water off the several points named in the first column on the routes to and from the places named in the heading of the table. The distances are measured at right angles to the co-tidal curves.

E.

Off—	Co-tidal hours on sailing lines between New York and—						
	Newport.	New Bedford.	Nantucket.	Boston.	Portsmouth.	Portland.	Halifax.
	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>h. m.</i>
Sandy Hook.....	.....	.....	.....	.....	.....	.....	12 5
Throg's Point.....	16 16	16 16	16 16	16 16	16 16	16 16	.....
Fisher's island.....	13 48	13 48	13 48	13 48	13 48	13 48	.....
Block island.....	12 16	12 16	12 16	12 16	12 16	12 16	11 30
Monomoy.....	.....	.....	.....	16 10	16 10	16 10	.....
Cape Cod.....	.....	.....	.....	14 35	14 35	14 35	12 15
Cape Ann.....	.....	.....	.....	.....	15 00	14 40	.....
Portland.....	.....	.....	.....	.....	.....	15 30	.....

In passing from New York to an eastern port the first great change in the tides and tidal currents is between the East river and Long Island sound; the difference between Governor's island and Negro Point, on Ward's island, at the eastern entrance to Hell Gate, is two hours and forty-five minutes. Between this point and Throg's Point the change is small. The mariner is now in the full tide of the sound, and between Throg's Point and Fisher's island there is a difference of time of but two hours and twenty minutes, the greatest part of which is at the head of the sound and at its entrance—that is, near Throg's Point and Fisher's island. From off New London to off Sand's Point the difference is but one hour and forty minutes; so that if the mariner, instead of remaining at Throg's Point, passes onward to Fisher's island, he would lose but half a tide in the whole passage. In other words, he would have the same succession of rise and fall, according to the time elapsed, whether stationary or passing onward, within two hours and a half, or less than half a tide.

The tidal current lines show that even a less allowance is to be made for the change of current than for the change of tide, the difference in the change of current between Throg's Point and Fisher's island, along the middle of the sound, being of no practical importance. Passing out of Long Island sound the tidal hours grow earlier, until off Block island that of Sandy Hook is again reached. The co-tidal line of Sandy Hook and Block island being the same, it is the struggle of the same tide through New York bay and the narrow East river, and obstructed Hell Gate, and through Fisher's island and Long Island sound, and to Throg's Point. The tidal currents meet near Throg's Point.

The lower part of Narraganset bay has the co-tidal hour twelve hours, nearly. Buzzard's bay has nearly the same co-tidal hour, the tide wave reaching the shore at nearly the same time all around the bay.

It would be impossible to give in a small compass a minute account of the tides of Martha's Vineyard and Nantucket sound. In general, it may be said that as far as Holmes's Hole and Wood's Hole they resemble those of Block Island sound, and afterwards those of Monomoy, at the eastern entrance; but this generalization is unsatisfactory without more details than there is space here to give. In these sounds takes place the remarkable change of between three and four hours, the greatest change of our coast, dislocating, as it were, the times of high water at places south and west and east and north of Nantucket. The whole of this change takes place between the eastern entrance of Nantucket sound and the western of Martha's Vineyard, giving rise to quite a complex condition of both tides and currents, which it has occupied much time to unravel. The dominant co-tidal line of our coast, from Block island to Cape Cañaveral, is that of 12 hours of Greenwich time; that of our eastern coast, from Nantucket to Passamaquoddy, is, in general, 15 hours. Passing out of Nantucket sound, coasters carry nearly the same co-tidal hour to Cape Cod, and thence vary their time about half an hour in passing to Boston, to Portsmouth, to Portland, or to Passamaquoddy. It has long been known that the tidal almanac for Boston might practically be used for eastern ports. Vessels from New York to Halifax, and New York to Europe, which keep outside, and should keep well off the Nantucket shoals, and off George's, as shown by the track on the chart, vary their co-tidal hour but little, keeping between the lines of 12 and $11\frac{1}{2}$ until quite well on their course, and beyond Cape Sable. The same rule will apply to their case as has been given for vessels between New York and a southern port.

APPENDIX No. 9.

REPORT TO THE SUPERINTENDENT BY ASSISTANT L. F. POURTALES, IN CHARGE OF THE FIELD AND OFFICE WORK, RELATING TO TIDAL OBSERVATIONS.

COAST SURVEY OFFICE, *October 1, 1864.*

SIR: I have the honor to submit the following report on the field and office work performed by the tidal party under my charge during the past year.

Field-work.—The following permanent tidal stations have been continued uninterrupted during the year ending at this date: Boston, Mass., New York, Old Point Comfort, Va., San Diego, and San Francisco, Cal., and Astoria, Oregon. The station at Eastport remained in charge of Assistant E. Goodfellow until April 1, his place being then taken by Sub-Assistant A. T. Mosman. On July 18 the station was discontinued, and the instruments were transferred to Portland, Me., where they were set up by Mr. H. W. Richardson, and started on the first of August.

Mr. M. C. King, the observer at Old Point Comfort, resigned the position, which he had filled satisfac-

torily since the establishment of the station, on the 1st of March. Since that date the station has been in charge of Ordnance Sergeant C. Kelly, U. S. A.

A self-registering tide-gauge was set up at Bay Point, Port Royal sound, S. C., by Assistant C. O. Bontelle; observations began August 22, but were unsatisfactory, the locality being too much exposed. The gauge will be transferred to a more sheltered place in the same sound.

The three stations on the western coast have, as in preceding years, been under the efficient supervision of Captain G. H. Elliot, of the corps of engineers, U. S. A.

The observations at most of the stations have been of a satisfactory character.

The following table gives a recapitulation of the tidal observations received during the past year, exclusive of those taken by the hydrographical parties for the reduction of their soundings.

Section.	Station.	Observer.	Kind of gauge.	Station, permanent or temporary.	Time of occupation.		Total days.	Remarks.
					From—	To—		
I	Eastport, Me.....	E. Goodfellow, A. T. Mosman.	S. R.	Permanent.	Oct. 1	July 18	292	Day tides for comparison with Governor's island.
I	Portland, Me.....	H. W. Richardson	do.	do.	Aug. 1	Sept. 30	61	
I	Boston Dry Dock.....	T. E. Ready	Box	do.	Oct. 1	do.	366	
II	Governor's island, N. Y.....	R. T. Bassett	S. R.	do.	do.	do.	366	
II	Brooklyn, N. Y.....	do.	Box	do.	do.	do.	366	
III	Old Point Comfort, Va.....	M. C. King, C. Kelly.....	S. R.	do.	do.	do.	366	
V	Port Royal, S. C.....	C. O. Bontelle	do.	do.	Aug. 22	Sept. 18	28	
X	San Diego, Cal.....	A. Cassidy.....	do.	do.	Oct. 1	Sept. 30	366	
X	San Francisco, Cal.....	H. E. Uhrlandt	do.	do.	do.	do.	366	
XI	Astoria, Oregon.....	L. Wilson	do.	do.	do.	do.	366	

Office-work.—The following persons have been attached to this division of the office during the past year, though never all at the same time: R. S. Avery, J. Downes, P. H. Donegan, M. Thomas, and F. R. Pendleton.

Mr. R. S. Avery remained connected with this division until the end of October, 1863, being engaged in revision of tidal reductions. He was then transferred to the computing division.

Mr. P. H. Donegan read off the times and heights of tides from the sheets of the self-registering tide-gauges, and made the reductions of the same. He was transferred to the charge of the archives on the first of April.

Mr. J. Downes took Mr. Donegan's place on the first of April, and continues on the same work at this time.

M. Thomas continues to copy the readings of the self-registering tide-gauges for preservation in the archives; also does miscellaneous clerical work.

F. R. Pendleton has continued to make the reductions of the observations from the western coast.

Very respectfully, your obedient servant,

L. F. POURTALES,

Assistant United States Coast Survey, in charge of tidal division.

Prof. A. D. BACHE, LL.D., *Superintendent United States Coast Survey.*

ON OBSERVATIONS OF TIDES AT TAHITI, MADE UNDER THE DIRECTION OF CAPTAIN JOHN RODGERS, U. S. N., (Sketch No. 40.)

The tides at Tahiti have long been known to exhibit the peculiarity of occurring nearly at the same hour of every day, indicating an almost total elimination of the lunar tide.

As far as we know, the tides of no other part of the globe present this extraordinary feature. No explanation fully satisfactory has yet been proposed for this phenomenon.

From their bearing on the laws regulating the tides on the North American coast of the Pacific ocean, accurate tidal observations in central parts of that ocean were a great desideratum, and advantage was, therefore, taken of the surveying expedition, under the command of Captain John Rodgers, U. S. N., by furnishing him with one of Saxton's self-registering tide-gauges, with the request to set it up at some suitable point.

The town of Papeete, on the island of Tahiti, was selected by Captain Rodgers, and the tide-gauge left there in 1856 under the charge of an intelligent French soldier. The observations began on the 27th of April, but up to June 2 were so frequently interrupted as to be of little use. After that date they are nearly complete to October 12, subsequent to which time no observations have been received.

On the accompanying diagram (see Sketch No. 40) the mean local time of each high water has been plotted in such a manner that the abscissae represent the days of the month; the ordinates the hours of the day. An inspection of the diagram will show that during part of the month of June the tide appears to have followed the general rule, occurring later every day, so that there was a high-water successively at all the hours of the twenty-four. In July, however, the case was quite different. The high-waters occurred at a later hour on successive days, but only until they had reached three or four hours, and in one case five, after noon or midnight, when they came back abruptly to the neighborhood of twelve, to follow again a similar cycle. This type they preserve to October 12, when the observations ceased, only the range and the abruptness of the return to an earlier hour becoming lessened. It will also be remarked that the midnight tides diverge less from that hour than the midday tides from noon. The times of low water have, as may be expected, similar relations to 6 a. m. and 6 p. m.

Taking the mean of all the observations we find 59 minutes past noon and 53 minutes past midnight for the average time of high water, and 45 minutes past six for the average time of low water, both morning and night.

Diagram 2 (Sketch No. 40) shows the variations from that mean, arranged according to the moon's transit. The curve exhibited might be called the half-monthly inequality in the soli-tidal interval, in analogy to the curve of half-monthly inequality, of the luni-tidal interval of ordinary tides.

With regard to the heights the statements received are not quite precise as to the scale used in the self-registering tide-gauge, and some uncertainty arises from the zero-point having been repeatedly altered, owing to the necessity of using the same paper on the gauge several times. On the best supposition that can be made we find the mean rise and fall to be 0.87 ft. The observations made at the same port for a few days by Captain Sir Edward Belcher, R. N., in 1840, (Phil. Trans., 1843,) gave a mean rise and fall of only 0.56 ft. The diurnal inequality is well marked, and the half-monthly inequality regular and normal.

If we examine the variations of the intervals near the time of the summer solstice, we shall find that, on the 3d of June or a little after, the moon's upper transit comes at noon; the intervals for midday tides is at its mean value. Then the interval increases rapidly every day as the moon's transits come later, until they come near the middle of the afternoon, when there is a sudden change of 6*h.* or 8*h.* in the course of two or three days, during which time the tides are so small that their times and intervals cannot be well determined. The high-waters then seem to pass under the influence of the moon's inferior transits, and the intervals are reduced to their minimum values, or become negative. The intervals then increase rapidly again for a considerable part of half a lunation until they pass again under the action of, and finally under the control of, the moon's superior transits. The same law will be observed to prevail throughout the period of observation, but the inequality rapidly decreases in amount as we depart from the solstice. Similar observations apply *mutatis mutandis* to the midnight tides.

The range of the tides seems to be considerably less near the solstice than they are near the equinox.

There seem to have been some notable changes in the mean level of the ocean in the month of July.

Hopes were entertained of obtaining more observations, and a supply of paper was forwarded to the United States consul some years ago, but no answer has ever been received. It has been thought advisable, therefore, to publish the results as far as they have been obtained.

APPENDIX No. 10.

REPORT OF ASSISTANT J. E. HILGARD, IN CHARGE OF THE OFFICE.

COAST SURVEY OFFICE, *Washington, November 1, 1864.*

SIR: I have the honor to submit herewith the annual report of the operations of the Coast Survey office which has remained under my charge during the past year.

In the general direction of the office I was assisted until June by Prof. F. A. P. Barnard, who then withdrew to fill the chair of president of Columbia College. The loss of his valuable assistance has been severely felt, but the impress of his mind and the marks of his shaping hand upon every subject that passed under his care will long remain.

The clerical duties of the office have been efficiently performed, as during the preceding year, by Mr. V. E. King, aided by Mr. Wm. Gadsby, jr. Upon the retirement of Prof. Barnard, that portion of his duties relating to the issue of maps and charts was assumed by Mr. King.

To Samuel Hein, esq., the disbursing officer of Coast Survey, and to Joseph Saxton, esq., the assistant in charge of the office of weights and measures, I beg leave to express my indebtedness for aid derived from their advice and experience.

The detailed accounts of the work performed in the several divisions of the office are herewith presented.

J. E. HILGARD,

Assistant Coast Survey, in charge of office.

HYDROGRAPHIC DIVISION.—The operations in this division have been continued under the direction of *Captain C. P. Patterson*. These, as heretofore, have included the arrangement of hydrographic matter for the hands of the engraver, the verification of charts, and the preparation of supplementary data for revised editions of sheets already published. The outfit and repairs of vessels used by the field parties have, as usual, been supervised by Captain Patterson. For office details two draughtsmen were on duty during the greater part of the year. Their occupation has been as follows:

Mr. Arthur Balbach made, under the direction of Captain Patterson, the comparisons and verification necessary in advance of the issue of charts from the office; the arrangement of notes for the charts; most of the plotting required in the preparation of new charts, as also that needed for new editions of sheets heretofore published. During part of the year Mr. Balbach was employed in the special survey of Boston harbor.

Mr. Louis Karcher continued the usual routine of service in the division until the end of September. He made the projections for the hydrographic sheets of the year; plotted original hydrographic work, and made reductions and verifications. His acceptable services terminated on the 1st of October, when he resigned.

TIDAL DIVISION.—The following report of the occupation in this division during the past year is submitted by *Assistant L. F. Pourtales*.

Mr. R. S. Avery remained connected with this division engaged in revision of tidal reductions until the end of October, 1863, when he was transferred to the computing division.

Mr. P. H. Donegan made the readings from the sheets of the self-registering tide-gauges and reduced the results. He was detached from this division and put in charge of the archives on the 1st of April.

Mr. J. Downes was assigned to this division, in Mr. Donegan's place, on the 1st of April, and has continued the work up to this time.

M. Thomas has continued to do the copying required, particularly of the readings of the self-registering tide-gauges, in shape for preservation in the archives.

F. R. Pendleton has continued to make the reductions of the observations from the western coast.

COMPUTING DIVISION.—The duties of the division in charge of *Assistant C. A. Schott* have been increased by the assignment of certain astronomical longitude computations, but no addition has been made to the effective force employed in it.

Mr. R. S. Avery, formerly of the tidal division of the office, joined the computers on the 28th of October, 1863. *Mr. James Main* resigned on the 1st of August, 1864, on account of ill health. He had been connected with the survey (excepting for a short period in 1859) since November, 1851; by his resignation the office loses an experienced and industrious computer.

In consequence of the assignment to this division of the reduction of the observations of Pleiades occultations between 1856 and 1861 for the determination of American longitudes and correction of the lunar ephemeris, according to the plan of Prof. Benjamin Peirce, and under his general direction, the distribution of the work assigned to the several computers has been slightly modified. *Mr. Main* was engaged on the first computation of the occultations, and *Mr. Avery* on the second or check computation. *Mr. Main's* place was afterwards filled by *Mr. Werner*, to whom the same duty was assigned.

On the night of November 13-14, 1863, *Mr. Schott* observed and recorded the phenomena of shooting stars, assisted by several observers. He was engaged between November 16 and November 22, 1863, in investigating the deflection of the compasses of the turreted iron-clad steamer *Roanoke*, then lying off Newport News, in James river. In July and August he determined and located ranges of projectiles fired from 15-inch guns, mounted on the shore of the Potomac, below Alexandria, and in September and October assisted in determining ranges of similar guns in New York and Boston harbors. His reports on various subjects this year include: The fourth report on deflections of compasses in iron-clad vessels, (see report of the compass committee, report of the National Academy;) a table of observations of shooting stars; results of a discussion of the compensation of base bars; a paper on the geodetic n point problem; a paper on great circle sailing on the polyconic projection; a report on the least square reduction of the primary triangulation in Section I, and

application to that portion connecting it with the Epping base; formulæ and application for ricochet shots. Over 1,000 separate observations of occultations of the Pleiades have been collected, about 700 of which will be submitted to reduction. Mr. Schott also attended to the comparison of the two computations before mentioned, and furnished information as needed by either field or office parties.

The following detailed statement shows the work performed by each computer:

Assistant Theodore W. Werner completed the reduction of the following triangulations: Penobscot bay, Section 1, 1862, G. A. Fairfield, observer; Neuse river, N. C., 1863, same observer; coast of New Jersey, south of Navesink, N. J., 1861-'62-'63, J. Farley, observer; vicinity of Baltimore, 1863, C. H. Boyd, observer; small additional triangulation, by G. Davidson, of the Canal de Haro, 1854; St. George's river, 1863, Chas. Ferguson, observer; Charlotte harbor, Fla., 1860-'61, W. R. Terril, observer; Penobscot bay, Me., 1863-'64, S. C. McCorkle, observer; he also made some miscellaneous computations, and a second computation of the horizontal angles at stations Mt. Pleasant, Thompson, and partly of Beaconpole; furnished an abstract of angles of the triangulation near Machias bay, Me., and commenced the reduction of the observations of the Pleiades occultations between 1856 and 1861. Mr. Werner was prostrated by sickness in April and part of May.

Mr. Eugene Nulty completed the reduction of the Penobscot bay triangulation, 1862, S. C. McCorkle, observer; and nearly completed the calculations for time, latitude, and telegraphic longitudes, also of azimuth and magnetic variation, at eleven stations in Western Virginia, Ohio, and Maryland, 1864, G. W. Dean and party, observers. He then took up geodetic computations, and also performed some work on daily magnetic records.

Mr. James Main completed the reduction of Assistant Schott's magnetic observations, in Section I, 1863, attended to some miscellaneous astronomical computations, and was engaged since October 28, 1863, on the first reduction of observations of Pleiades occultations. He resigned August 1, 1864.

Dr. Gottlieb Rumpf prepared the annual statistics of the geodetic operations; attended to the geographical registers; prepared the geographical positions determined for publication; revised horizontal angles, station Beaconpole; revised the computation of the triangulation near Baltimore, 1863, and of Penobscot bay, 1862; computed the triangulation between Machias and Passamaquoddy bays, 1863; attended to miscellaneous geodetic work; assisted in the least-square reduction of the primary triangulation near the Epping base, and to the south and westward; and computed probable errors of the directions of this triangulation.

Mr. R. S. Avery was transferred to this division, October 28, 1863, for the purpose of making the check computation for longitudes from observations of the Pleiades, upon which work he has been engaged since, making very satisfactory progress.

Mr. E. H. Courtenay attended to the clerical duty of the division—to copying for permanent record and for field parties; converted measures, and performed some other computations connected with horizontal angles. He also completed the duplicate records of the survey (geodetic and astronomical) prior to 1844.

R. Freeman was during part of the year supplied with miscellaneous copying.

The duplicate records of geodetic, astronomical, and magnetic observations, still in my special charge, number 1,542 volumes.

DRAWING DIVISION.—Under the immediate direction of Assistant Hilgard the work has been distributed in this division by Mr. W. T. Bright. The occupation of the several draughtsmen has been as follows:

Assistant M. I. McClery has continued filling in details upon the photographed outline of coast maps No. 10, Cape Ann to Plymouth harbor, Mass., and No. 53, Rattlesnake shoals to St. Helena sound, S. C., scale $\frac{1}{80000}$; the hill topography of coast map No. 10, Cape Ann to Plymouth harbor, Mass., and that of No. 11, Plymouth harbor to Hyannis harbor, Mass., on a scale of $\frac{1}{40000}$, to be reduced by photography to the scale of $\frac{1}{80000}$. He has traced for photographing the special survey of part of the Ohio river, from Cairo to Mound City, and drawn portions of topography for a finished map of Potomac river, sheet No. 1, scale $\frac{1}{60000}$.

Mr. E. Hergesheimer, as usual, has had charge of the preparation of tracings from plane-table sheets for photographic reduction to the publication scale of coast maps No. 8, Seguin island to Kennebunk Port, Me.; No. 10, Cape Ann to Plymouth harbor, Mass.; No. 11, Plymouth harbor to Hyannis harbor, Mass.; No. 53, Rattlesnake shoals to St. Helena sound, S. C.; No. 54, St. Helena sound, S. C., to Ossabaw sound, Ga.; also upon the finished map of Hudson river, sheet No. 1, New York to Haverstraw, scale $\frac{1}{80000}$, and Boston harbor, (new edition,) scale $\frac{1}{40000}$. He revised the hydrography of the preliminary chart of Potomac river, sheet No. 2, Piney Point to Lower Cedar Point, scale $\frac{1}{60000}$; compiled a road map of Washington and vicinity for the use of the army; made a manuscript map for military purposes of Wilmington and vicinity, N. C., and

has drawn the hill topography of the map of Appomattox and James rivers, Va., for photographing. He also added supplementary details to the chart of Washington sound, (new edition;) finished hill topography for the map of Grand Gulf, Miss.; made the additions of the year to the Congress map; arranged the lettering for all the finished maps and charts in process of publication, and has made verifications, projections for field parties, and diagrams. Between June 18 and July 30 Mr. Hergesheimer was engaged for the Quartermaster General U. S. A., in a topographical survey of the Soldiers' National Cemetery, at Arlington, Va.

Mr. A. Lindenkohl was engaged with the late Lieutenant J. R. Meigs, corps of engineers, in West Virginia, from October 3, 1863, until February 15, 1864, since which time he has compiled additional material for the military maps of the mountain region of Tennessee and North Carolina, southeastern Virginia, eastern Virginia, and the northern part of Florida, and for extending the limits of maps used in the armies so as to include nearly the entire area of the States in rebellion upon a uniform scale of ten miles to the inch. He has completed the preliminary chart of the Atlantic coast No. 1, Cape Sable to Barnegat inlet, scale $\frac{1}{120000}$, and made additions to that of the Gulf coast, from Mobile Point to Corpus Christi bay, Texas, scale $\frac{1}{120000}$; continued the drawing of preliminary chart of part of the western coast of the United States, from Point Pinos to Bodega Head, including the bay of San Francisco, scale $\frac{1}{200000}$; completed preliminary chart of Half Moon bay, Cal., scale $\frac{1}{200000}$; Cape Lookout shoals, N. C., scale $\frac{1}{80000}$; Light-house inlet and the inland passage to Folly river, S. C., scale $\frac{1}{200000}$; made additions to the preliminary chart of Nantucket shoals, scale $\frac{1}{200000}$, and has drawn, as far as the material goes, a chart of Eastport harbor, Me., scale $\frac{1}{80000}$. He has reduced additional hydrography for coast chart No. 7, Muscongus bay to Portland, Me.; No. 8, Seguin island to Kennebunk Port, Me.; and Nos. 40 and 41, Albemarle sound, N. C., scale $\frac{1}{80000}$, and has made projections on copper, projections for field parties, progress sketches, additions from time to time to the published war maps, and special lithographic maps for the Navy Department.

Mr. L. D. Williams, until November 30, when he resigned, was engaged upon projects, copper-plate projections, lettering, additions to the Congress map, and verifications.

Mr. H. Lindenkohl has selected and traced for reduction by photography the remaining hydrography for the chart of Kennebec and Sheepscot rivers, Me., scale $\frac{1}{40000}$; continued the hydrographic reduction of Port Royal sound, including Beaufort, Broad, and Chechessee rivers, S. C., scale $\frac{1}{80000}$, and reduced additional topography for sheet No. 4, of Potomac river, (Indian Head to Little Falls bridge,) scale $\frac{1}{40000}$. Besides drawing the hill topography, on the scale of the original survey, for a map of Vicksburg and approaches, he made additions to the chart of Albemarle sound, N. C., scale $\frac{1}{200000}$, and engraved on stone from his own drawing a map of the city of Richmond, Va., and portions of other maps of the States in rebellion. He has also been engaged upon projections, progress sketches, and tracings of various kinds.

Mr. Lindenkohl, after a career of great usefulness in the office, sailed for Europe in August.

Mr. F. Fairfax has drawn the hill topography for a map of Bodega bay, Cal., scale $\frac{1}{30000}$; made additions to that of Newport harbor, R. I., scale $\frac{1}{20000}$, and traced for photographing the topography of St. Helena sound, S. C., scale $\frac{1}{40000}$, and that of Tomales bay, Cal., scale $\frac{1}{30000}$. He has prepared for engraving the details upon a photographed outline of Rockland harbor, Me., scale $\frac{1}{20000}$; the topography for a chart of the main entrance to Charlotte harbor, Fla., scale $\frac{1}{40000}$, and additional topography for coast maps Nos. 40 and 41, Albemarle sound, N. C., scale $\frac{1}{80000}$, and for a preliminary chart of the sound on a scale of $\frac{1}{200000}$. He has also made projections for field parties, diagrams, and tracings, and is now engaged in reducing additional work for the chart of Delaware and Chesapeake bays, scale $\frac{1}{400000}$.

Mr. F. Engel during the time he was attached to the division was engaged upon diagrams, miscellaneous drawings, and reduction of material for a chart of the Atlantic coast, No. 1, (Cape Sable to Barnegat inlet,) scale $\frac{1}{120000}$.

Mr. W. B. McMurtrie continued on duty in Philadelphia, connected with the special survey, until January 26, since which time he has been employed in plotting hydrographic work, in tracing for photographic reduction, and in drawing the preliminary chart of Hudson river, from Glasco to Troy, scale $\frac{1}{40000}$, and that of the mouths of Roanoke river, N. C., scale $\frac{1}{30000}$. He has also been engaged upon projects for maps, in inking, plane-table sheets, and in tracing.

Mr. J. W. Maerdel was employed on photographic tracings and other miscellaneous work until December, 1863, when he was assigned to the party of Assistant C. O. Boutelle as hydrographic draughtsman.

Mr. E. Willenbacher, until August, when he was assigned to the party of Assistant Boutelle as hydrographic draughtsman, was engaged in plotting hydrographic work, in tracing, and in coloring proofs.

Mr. E. Molitor was assigned to duty in this division in December, 1863, and, until April 21, was engaged

on tracings, diagrams, verifications, and additions to the war maps, when he left the office to join the army. He rejoined the office in September, and, until the end of that month, aided in preparing for issue a new map of Mobile bay, when he again left.

Messrs. B. Hooc, J. H. Logan, and W. Fairfax have been engaged upon tracings, statistics, tracing for photographic reduction, inking plane-table sheets, and other miscellaneous work.

Mr. D. Koch was employed in the office from April until October upon tracings and coloring lights on charts.

ENGRAVING DIVISION.—The division has remained under the charge of Mr. Edward Wharton since the date of the last report. The duties of clerk to the division were performed, after Mr. G. J. Pinckard's resignation, which occurred in December, by Mr. Henry C. Saxton, until the 19th of May. Since the first of July the position has been filled by Mr. George C. Schaeffer, jr.

The engraving force at present consists of eighteen engravers of various degrees of skill. A detailed statement of the occupation of each, which differs but little from year to year, will be found below.

The engraving of the following finished maps and charts has been completed, viz: general chart of the coast No. X, Straits of Florida, Key Biscayne to Marquesas Keys, $\frac{1}{400000}$; Tomales bay, Cal., $\frac{1}{300000}$, and various additions in topography and hydrography, constituting new editions, have been made to Boston harbor, Mass., $\frac{1}{400000}$; Port Royal entrance, Beaufort, Broad and Chechessee rivers, S. C., $\frac{1}{800000}$; Key West harbor, Fla., $\frac{1}{300000}$, and Washington sound, W. T., $\frac{1}{200000}$. In addition to these, four charts of our coast on a scale of $\frac{1}{1200000}$ have been engraved—No. 1, extending from Cape Sable to Sandy Hook; No. 4, from Mosquito inlet to Key West—and a chart of the Gulf coast in two sheets, extending from Key West to the Rio Grande. A new edition has also been engraved of Nantucket shoals, $\frac{1}{200000}$; a sketch of Cape Lookout shoals, N. C., $\frac{1}{800000}$, and important additions made to the chart of San Pablo bay, Cal., $\frac{1}{300000}$.

The following charts have been prepared for preliminary editions, viz: Rockland harbor, Me., $\frac{1}{200000}$; Hudson river from Poughkeepsie to Troy, $\frac{1}{400000}$, in two plates; Hampton Roads and Elizabeth river, Va., $\frac{1}{400000}$; St. Helena sound, S. C., $\frac{1}{400000}$; coast chart Nos. 69 and 70, Florida reefs, from The Elbow to New-found Harbor Keys, $\frac{1}{800000}$; western end of Florida reefs, including the Tortugas Keys, $\frac{1}{200000}$; main entrance to Charlotte harbor, Fla., $\frac{1}{400000}$, and Half-moon bay, Cal., $\frac{1}{200000}$.

Considerable progress has also been made upon the following important charts, viz: Kennebec and Sheepscot rivers, Me., $\frac{1}{400000}$; coast charts Nos. 8, 10, and 11, scale $\frac{1}{800000}$, embracing portions of the coast from Portland, Me., to the extremity of Cape Cod, Mass.; Newport harbor, R. I., $\frac{1}{200000}$; Barnstable harbor, Mass., $\frac{1}{200000}$; coast chart No. 21, New York bay and harbor, $\frac{1}{800000}$, as a finished chart; Hudson river, sheet No. 1, from entrance to Haverstraw, $\frac{1}{800000}$; Potomac river, sheet No. 1, from entrance to Piney Point, $\frac{1}{800000}$; and sheet No. 4, from Indian Head to Little Falls, $\frac{1}{400000}$; coast chart No. 29, from Green Run inlet to Little Machipongo inlet, Md., $\frac{1}{800000}$; coast chart No. 48, from Barren inlet to Lockwood's Folly inlet, N. C., $\frac{1}{800000}$; coast chart No. 53, from Stono inlet to Fripps's inlet, S. C., $\frac{1}{800000}$; Calibogue sound and Skull creek, S. C., $\frac{1}{200000}$ and $\frac{1}{400000}$; coast chart No. 100, Point au Fer to Marsh island, La., $\frac{1}{800000}$; upper part of San Francisco bay, Cal., $\frac{1}{300000}$; Pacific coast from Point Piños to Bodega Head, Cal., $\frac{1}{200000}$, and Bodega bay, Cal., $\frac{1}{300000}$.

And the following charts have been commenced, viz: coast chart No. 28, from Cape Henlopen, Del., to Green Run inlet, Md., $\frac{1}{800000}$; a sketch of entrance to Roanoke river, N. C., $\frac{1}{300000}$; coast chart No. 54, from Fripps's inlet to Ossabaw sound, Ga., $\frac{1}{800000}$; Beaufort river and inland passage from Port Royal to St. Helena sound, S. C., $\frac{1}{400000}$, and Wassaw sound, Ga., $\frac{1}{400000}$.

The engraving force has been principally employed as follows:

Mr. J. Knight, letter engraver, has engraved additional soundings and lettering upon coast chart No. 8, from Seguin island to Kennebunk Port, Me., $\frac{1}{800000}$; the soundings, bottoms, and lettering upon coast chart No. 10, Cape Ann to Plymouth, Mass., $\frac{1}{800000}$; a portion of the soundings, general lettering, and the notes upon Hudson river No. 1, from entrance to Haverstraw, $\frac{1}{800000}$; various additions in hydrography, names and buoys upon coast charts Nos. 32 and 33, portions of Chesapeake bay, $\frac{1}{800000}$; the general lettering upon coast chart No. 53, Stono inlet to Fripps's inlet, S. C., $\frac{1}{800000}$; the title upon coast chart No. 100, Point au Fer to Marsh island, La., $\frac{1}{800000}$; the notes upon Gulf coast of the United States, eastern plate, $\frac{1}{1200000}$, and some additional lettering upon Pacific coast from Point Piños to Bodega Head, $\frac{1}{200000}$; and miscellaneous corrections and additions to various plates.

Mr. A. Rollé, topographical engraver, has completed the outlines and a portion of the topography upon coast chart No. 29, Green Run inlet to Little Machipongo inlet, Md., $\frac{1}{800000}$; a portion of the dry sand upon

the new edition of Boston harbor, Mass., $\frac{1}{40000}$, and has commenced the topography upon coast chart No. 28, from Cape Henlopen, Del., to Green Run inlet, Md., $\frac{1}{80000}$.

Mr. J. Enthoffer, topographical engraver, has continued, upon contract, the topography upon coast chart No. 21, New York bay and harbor, $\frac{1}{80000}$, upon which he is now engaged.

Mr. A. Sengteller, topographical engraver, has completed the outlines and is well advanced upon the topography of coast chart No. 53, Stono inlet to Fripps's inlet, S. C., $\frac{1}{80000}$, and engraved also a portion of the outlines of Rockland harbor, Maine, $\frac{1}{20000}$.

Mr. W. Phillips, topographical engraver, engraved the topography upon coast chart No. 69, Florida reefs, from The Elbow to Lower Matecumbe key, $\frac{1}{80000}$, and upon Tomales bay, Cal., $\frac{1}{30000}$; he engraved also the views for the plate of Pacific coast from Point Piños to Bodega Head, Cal., $\frac{1}{20000}$, and is now engaged upon the topography of Calibogue sound and Skull creek, S. C., $\frac{1}{20000}$ and $\frac{1}{40000}$.

Mr. H. C. Evans, topographical engraver, has continued the topography upon coast chart No. 8, Seguin island to Kennebunk Port, Me., $\frac{1}{80000}$, and upon coast chart No. 11, Plymouth to Hyannis, Mass., $\frac{1}{80000}$; continued, also, Hudson river, sheet No. 1, from New York to Haverstraw, $\frac{1}{60000}$, and is at present engaged upon the additional topography upon Kennebec and Sheepscot rivers, Me., $\frac{1}{40000}$.

Mr. H. S. Barnard, topographical engraver, has engraved all the sand upon San Francisco bay, Cal., upper part, $\frac{1}{50000}$, and a portion of the sand upon Kennebec and Sheepscot rivers, Me., $\frac{1}{40000}$; coast chart Nos. 69 and 70, Florida reefs, from The Elbow to Newfound Harbor keys, $\frac{1}{80000}$, and Pacific coast, from Point Piños to Bodega Head, Cal., $\frac{1}{20000}$, and corrections in sanding upon various plates.

Mr. A. M. Macdel, topographical engraver, has engraved a portion of the topography and outlines upon Potomac river, sheet No. 1, from entrance to Piney Point, $\frac{1}{60000}$, and upon sheet No. 4, from Indian Head to Little Falls, $\frac{1}{40000}$, and all the topography upon coast chart No. 48, from Barren inlet to Lockwood's Folly inlet, N. C., $\frac{1}{80000}$.

Mr. J. C. Kondrup, miscellaneous engraver, engraved with the pantagraph a portion of the outlines upon chart of the Atlantic coast, sheet No. 1, Cape Sable to Sandy Hook, $\frac{1}{120000}$; completed the outlines of coast chart No. 10, Cape Ann to Plymouth, Mass., $\frac{1}{80000}$; the entire outlines of coast chart No. 54, Fripps's inlet to Ossabaw sound, Ga., $\frac{1}{80000}$; has ruled a tint upon the new edition of Washington sound, W. T., $\frac{1}{20000}$, and engraved a portion of the outlines upon the new edition of Boston harbor, Mass., $\frac{1}{40000}$.

Mr. E. A. Macdel, jr., letter engraver, engraved the title and completed the soundings upon Kennebec and Sheepscot rivers, Me., $\frac{1}{40000}$; the title and notes upon Hudson river, sheet No. 3, from Poughkeepsie to Glasco, $\frac{1}{40000}$; the titles of coast chart No. 70, Florida reefs, from Long key to Newfound Harbor key, $\frac{1}{80000}$, and of Hudson river, sheet No. 1, from New York to Haverstraw, $\frac{1}{60000}$; various additions in lettering and buoys to coast chart No. 32, Chesapeake bay, from Magothy river to Choptank river, $\frac{1}{80000}$; the general lettering, notes, and bottoms to charts of the Atlantic coast No. 1., Cape Sable to Sandy Hook, No. 4, Mosquito inlet to Key West, and of the Gulf coast, in two plates, from Key West to the Rio Grande, $\frac{1}{120000}$, and is now engraving the title and notes upon coast chart No. 69, Florida reefs, from The Elbow to Lower Matecumbe key, $\frac{1}{80000}$.

Mr. A. Petersen, miscellaneous engraver, has engraved the soundings and general lettering of Potomac river, sheet No. 1, from entrance to Piney Point, $\frac{1}{60000}$; the shore-line, title, notes, and general lettering, complete, of two navy trial course plates, New York bay and Hampton Roads, $\frac{1}{40000}$; the title and lettering of St. Helena sound, S. C., $\frac{1}{40000}$; the title of Rockland harbor, Me., $\frac{1}{20000}$; the soundings and bottoms of coast chart No. 69, Florida reefs, from The Elbow to Lower Matecumbe key, $\frac{1}{80000}$, and the soundings, bottoms, and notes of coast chart No. 70, from Long key to Newfound Harbor key, $\frac{1}{80000}$.

Mr. R. F. Bartle, topographical engraver, has completed the marsh and grass upon Barnstable harbor, Mass., $\frac{1}{20000}$; a portion of the outlines of Rockland harbor, Me., $\frac{1}{20000}$; the sand on Potomac river, sheet No. 2, from Piney Point to Lower Cedar Point, $\frac{1}{60000}$, and Gulf coast of the United States, Key West to Rio Grande, in two sheets, $\frac{1}{120000}$, and is now engaged upon the topography of James river from City Point to Richmond, including the Appomattox river, $\frac{1}{40000}$.

Mr. F. W. Benner, miscellaneous engraver, has engraved the sand of Rockland harbor, Me., $\frac{1}{20000}$, Mount Hope bay, R. I., $\frac{1}{40000}$; the shore-line, sand, and marsh of Hudson river, No. 4, from Glasco to Troy, $\frac{1}{40000}$; the outlines and topography of entrance to Roanoke river, N. C., $\frac{1}{30000}$, and a large amount of miscellaneous work, and is now engaged upon the marsh and sand of Hudson river, No. 3, from Poughkeepsie to Glasco, $\frac{1}{40000}$.

Mr. W. A. Thompson, topographical engraver, has completed the sand upon James river from City

Point to Richmond, $\frac{1}{40000}$; Calibogue sound and Skull creek, S. C., $\frac{1}{20000}$ and $\frac{1}{40000}$; western end of Florida reefs, including the Tortugas keys, $\frac{1}{20000}$, and Half-moon bay, Cal., $\frac{1}{20000}$; a portion of the sand upon coast chart No. 48, Barren inlet to Lockwood's Folly inlet, N. C., $\frac{1}{80000}$; a portion of the outlines, all the sand, borders, curves, and compasses upon Atlantic coast of the United States, sheet No. 1, Cape Sable to Sandy Hook, and sheet No. 4, Mosquito inlet to Key West, $\frac{1}{120000}$; and is now engaged upon the topography of Bodega bay, Cal., $\frac{1}{30000}$.

Mr. E. H. Sipe, miscellaneous engraver, has engraved various corrections and additions to Albemarle sound, N. C., $\frac{1}{20000}$; the bottoms, curves, &c., to St. Helena sound, S. C., $\frac{1}{40000}$; the outlines and lettering complete, of diagrams Girard College observations 1863; besides miscellaneous work upon various plates; and is now engaged upon the soundings, title, and notes of Nantucket shoals, $\frac{1}{20000}$, new edition.

Mr. J. G. Thompson, jr., miscellaneous engraver, engraved the outlines of Wassaw sound, Ga., $\frac{1}{40000}$; a portion of the notes of Hampton Roads, Va., $\frac{1}{40000}$; additional shore-line and lettering of Port Royal entrance, S. C., $\frac{1}{40000}$; the outlines and dry sand of St. Helena sound, S. C., $\frac{1}{40000}$; the notes of Rockland harbor, Me., $\frac{1}{20000}$; title and notes of Half-moon bay, Cal., $\frac{1}{20000}$; and is now engaged upon the outlines, title, and notes of Charlotte harbor, Fla., $\frac{1}{40000}$.

Mr. A. Buckle has punched the figures of soundings upon the following plates: Rockland harbor, Me., $\frac{1}{20000}$; entrance Roanoke river, N. C., $\frac{1}{30000}$; Navy Trial Course, two plates, New York bay and Hampton Roads, $\frac{1}{40000}$; coast chart No. 48, Barren inlet to Lockwood's Folly inlet, N. C., $\frac{1}{80000}$; St. Helena Sound, S. C., $\frac{1}{40000}$; Charlotte harbor, Fla., $\frac{1}{40000}$; Half-moon bay, Cal., $\frac{1}{20000}$; Atlantic coast of the United States, sheet No. 1, Cape Sable to Sandy Hook, $\frac{1}{120000}$; Cape Lookout shoals, N. C., $\frac{1}{80000}$; Light-house inlet, S. C., $\frac{1}{20000}$, Hudson river, No. 4, from Poughkeepsie to Troy, $\frac{1}{40000}$; Beaufort river and Inland Passage, from Port Royal to St. Helena sound, S. C., $\frac{1}{40000}$, and a portion of the soundings upon Port Royal entrance, S. C., $\frac{1}{60000}$, and Wassaw sound, Ga., $\frac{1}{40000}$, besides some miscellaneous work and practice.

Mr. W. H. Davis has engraved the sailing directions and notes upon the new edition of Key West harbor, Fla., $\frac{1}{30000}$, and a portion of the notes for the new edition of Port Royal entrance, S. C., $\frac{1}{80000}$; the title, notes, and lettering of Cape Lookout shoals, N. C., $\frac{1}{80000}$; besides work upon progress sketches, and miscellaneous work and practice.

CATALOGUE OF HYDROGRAPHIC MAPS, CHARTS, AND SKETCHES PUBLISHED BY THE UNITED STATES COAST SURVEY TO NOVEMBER, 1864.

The maps and charts embraced in the following catalogue are of two general descriptions, which may be distinguished as *preliminary* and *finished*. The preliminary charts are those which are issued as soon after the several surveys as is consistent with accuracy of general delineation, and are designed to supply the immediate and pressing demands of navigation. The finished charts embody *all* the information furnished by the survey, including the minutest details; and embrace not only the hydrography, but the topography likewise. The two classes of charts differ in regard to the *amount* of the information which they furnish, but not in regard to the correctness of that which is given.

The charts are various in character, according to the objects which they are designed to subserve. The most important distinctions are the following:

1. *Sailing charts* upon a scale of $\frac{1}{120000}$, embracing the largest area of any, and designed to enable the navigator to protract his course. Four of these cover the entire Atlantic coast of the United States, and two others embrace the entire coast of the Gulf of Mexico.
2. *General charts of the coast*, on a scale of $\frac{1}{40000}$, for off-shore navigation. These represent the shore-line and its characteristic features, so as to be readily recognized by the navigator approaching it. The entire Atlantic and Gulf coasts will be comprehended in sixteen charts of this class.
3. *Preliminary sea-coast charts*, on a scale of $\frac{1}{20000}$, for in-shore navigation. These will all be ultimately superseded by the more complete charts next to be named.
4. *Coast charts* for in-shore navigation, on a scale of $\frac{1}{80000}$, exhibiting with minute accuracy every natural and every permanent artificial feature, above or below the water, which can be introduced without occasioning confusion. They exhibit, also, the topography for some distance from the shore.

Besides the foregoing, there are numerous charts of harbors, bays, anchorages, &c., and sketches of local dangers, on various scales.

EXPLANATION OF THE SCALES.

A nautical mile contains 6,076 feet, or 72,912 inches.

Upon a scale of	$\frac{1}{100000}$	a nautical mile is represented by	$7\frac{3}{16}$	inches.
" "	$\frac{1}{800000}$	" " "	$\frac{9}{16}$	of an inch, nearly.
" "	$\frac{1}{2000000}$	" " "	$\frac{3}{8}$	" " "
" "	$\frac{1}{4000000}$	" " "	$\frac{3}{16}$	" " "
" "	$\frac{1}{5000000}$	" " "	$\frac{1}{8}$	" " "
" "	$\frac{1}{12000000}$	" " "	$\frac{1}{16}$	" " "

The charts in the following Catalogue are arranged in geographical order, beginning at the northeastern boundary of the United States, and proceeding regularly along the coast of the Atlantic and Gulf of Mexico to the mouth of the Rio Grande; and afterwards beginning at San Diego bay, on the Pacific, and proceeding regularly northward to the northwestern boundary.

ATLANTIC COAST.

ABBREVIATIONS.—F., Finished; Pr., Preliminary; Sk., Sketch.

TITLE.	Class.	Size of border.	Scale.	Date of last edition.
SAILING CHARTS.				
Atlantic coast of the United States:				
I. Cape Sable to Sandy Hook	Pr.	24 × 28	$\frac{1}{1,200,000}$	1864
II. Nantucket to Cape Hatteras.	Pr.	24 × 28	do.	1864
III. Cape Hatteras to Mosquito inlet	Pr.	24 × 28	do.	1864
IV. Mosquito inlet to Key West, with Bahama Banks.	Pr.	24 × 28	do.	1864
Gulf coast of the United States:				
Key West to Rio Grande.	Pr.	28 × 52	do.	1864
GENERAL CHARTS OF THE COAST.				
No. III. From Gay Head to Cape Henlopen.	F.	31 × 38½	$\frac{1}{400,000}$	1852
No. IV. From Cape May to Cape Henry.	Pr.	31 × 38	do.	1863
No. X. Straits of Florida, from Key Biscayne to Marquesas keys.	Pr.	31 × 38	do.	1860
COAST AND HARBOR CHARTS.				
Eastport harbor.	Pr.	17 × 20	$\frac{1}{40,000}$	1864
Sea-coast chart, No. 3, Small Point, Me., to Cape Cod, Mass.	Pr.	31 × 37	$\frac{1}{200,000}$	1859
Eggemoggin Reach.	Sk.	9 × 11	$\frac{1}{20,000}$	1854
Rockland harbor.	Pr.	19 × 21	do.	1863
Rockport and Camden harbors.	Pr.	14 × 17	do.	1864
Kennebec and Sheepscot rivers.	Pr.	23½ × 38½	$\frac{1}{40,000}$	1863
Casco bay, approaches to Portland.	Pr.	21 × 30½	$\frac{1}{80,000}$	1863
Portland harbor.	F.	26 × 29	$\frac{1}{20,000}$	1862
Richmond's Island harbor.	F.	14 × 17	do.	1851

REPORT OF THE SUPERINTENDENT OF
Coast and Harbor Charts—Continued.

TITLE.	Class.	Size of border.	Scale.	Date of last edition.
Portland harbor, showing wharf line recommended by city commissioners.....	Sk.	<i>Inches.</i> 20½ × 22	$\frac{1}{10,000}$	1855
York River harbor.....	F.	12½ × 16	$\frac{1}{20,000}$	1854
Portsmouth harbor.....	Pr.	19 × 27	do.	1854
Isles of Shoals.....	F.	14 × 17	do.	1864
Newburyport harbor.....	F.	17 × 24½	do.	1855
Ipswich and Annisquam harbor.....	F.	19 × 29	do.	1857
Rockport harbor.....	F.	14 × 17½	do.	1859
Gloucester harbor.....	F.	14 × 18	do.	1855
Salem harbor.....	F.	21 × 28	$\frac{1}{25,000}$	1859
Lynn harbor.....	F.	14½ × 17½	$\frac{1}{20,000}$	1859
Boston harbor.....	F.	28½ × 36	$\frac{1}{40,000}$	1857
Boston bay and approaches.....	Pr.	30 × 29	$\frac{1}{80,000}$	1864
Sea-coast Chart, No. 4, from Cape Cod, Mass., to Saugkonnet Point, R. I.....	F.	29½ × 31½	$\frac{1}{200,000}$	1857
Plymouth harbor.....	F.	19½ × 23	$\frac{1}{20,000}$	1857
Barnstable harbor.....	Pr.	16½ × 23	do.	1861
Wellfleet harbor.....	F.	14 × 17½	$\frac{1}{50,000}$	1853
Provincetown harbor.....	F.	14½ × 17½	do.	1857
Nantucket shoals.....	Pr.	23½ × 19½	$\frac{1}{200,000}$	1863
Coast from Monomoy and Nantucket shoals to Block island, (in three sheets,) viz:				
1. From Monomoy and Nantucket shoals to Muskeget channel, Mass., Coast Chart, No. 12.	F.	27½ × 37½	$\frac{1}{80,000}$	1860
2. From Muskeget channel to Buzzard's bay and entrance to Vineyard sound, Mass., Coast Chart, No. 13.	F.	do.	do.	1860
3. From entrance to Buzzard's bay to Block island, R. I., Coast Chart, No. 14.....	F.	do.	do.	1860
Bass River harbor.....	F.	13½ × 16½	$\frac{1}{40,000}$	1857
Hyannis harbor.....	F.	14½ × 18½	$\frac{1}{30,000}$	1850
Nantucket harbor.....	F.	14 × 17	$\frac{1}{20,000}$	1848
Muskeget channel.....	F.	21 × 28	$\frac{1}{60,000}$	1859
Edgartown harbor.....	F.	14½ × 17½	$\frac{1}{20,000}$	1848

Coast and Harbor Charts—Continued.

TITLE.	Class.	Size of border.	Scale.	Date of last edition.
<i>Holmes's Hole and Tarpaulin Cove harbors</i>	F.	<i>Inches.</i> 14 × 17½	$\frac{1}{20,000}$	1847
<i>Wood's Hole harbor</i>	F.	13 × 17½	do.	1857
<i>Sippican harbor</i>	Pr.	14½ × 18	do.	1864
<i>New Bedford harbor</i>	F.	14½ × 18	$\frac{1}{40,000}$	1850
<i>Mount Hope bay</i>	Pr.	16 × 19	do.	1861
<i>Bristol bay</i>	Pr.	13 × 17	$\frac{1}{20,000}$	1863
<i>Newport harbor</i>	Pr.	13 × 17	do.	1863
<i>Dutch island</i>	F.	14½ × 17½	$\frac{1}{10,000}$	1863
<i>Long Island sound, (in three sheets,) viz:</i>				
1. <i>Eastern part, Coast Chart, No. 15</i>	F.	25½ × 35½	$\frac{1}{80,000}$	1855
2. <i>Middle part, Coast Chart, No. 16</i>	F.	do.	do.	1855
3. <i>Western part, Coast Chart, No. 17</i>	F.	do.	do.	1855
<i>Fisher's Island sound</i>	F.	14 × 17½	$\frac{1}{40,000}$	1847
<i>New London harbor</i>	F.	14 × 17½	$\frac{1}{20,000}$	1848
<i>Mouth of Connecticut river</i>	F.	14 × 17½	do.	1853
<i>Hart and City islands and Sachem's Head harbors</i>	F.	14 × 17½	$\left\{ \begin{array}{l} \frac{1}{20,000} \\ \frac{1}{10,000} \end{array} \right\}$	1851
<i>New Haven harbor</i>	F.	14 × 17½	$\frac{1}{30,000}$	1846
<i>Black Rock and Bridgeport harbors</i>	F.	14 × 17½	$\frac{1}{20,000}$	1848
<i>Sheffield Island and Cawkin's Island harbors</i>	F.	14 × 17½	do.	1848
<i>Captain's islands, East and West harbors</i>	F.	14 × 17½	do.	1849
<i>Hempstead harbor</i>	F.	14½ × 18	do.	1859
<i>Oyster or Syosset Bay harbor</i>	F.	14 × 17½	$\frac{1}{30,000}$	1847
<i>Huntington bay</i>	F.	14 × 17½	$\frac{1}{300,000}$	1849
<i>Southern coast of Long Island, (in three sheets,) viz:</i>				
1. <i>Eastern part, Coast Chart, No. 18</i>	F.	25 × 35	$\frac{1}{80,000}$	1857
2. <i>Middle part, Coast Chart, No. 19</i>	F.	do.	do.	1857
3. <i>Western part, Coast Chart, No. 20</i>	F.	do.	do.	1851

Coast and Harbor Charts—Continued.

TITLE.	Class.	Size of border.	Scale.	Date of last edition.
Hell Gate and approaches.....	F.	<i>Inches.</i> 25 × 36	$\frac{1}{5,000}$	1851
New York bay and harbor.....	Pr.	27 × 31	$\frac{1}{80,000}$	1861
Hudson river, (in three sheets,) viz:				
No. 1. New York to Haverstraw.....	F.	17½ × 40	$\frac{1}{60,000}$	1863
No. 2. Haverstraw to Poughkeepsie.....	Pr.	17½ × 40	do.	1861
No. 3. Poughkeepsie to Troy.....	Pr.	34 × 40	$\frac{1}{40,000}$	1863
Little Egg harbor.....	F.	14 × 17½	$\frac{1}{30,000}$	1846
Absecom inlet.....	F.	14½ × 17½	$\frac{1}{20,000}$	1864
Delaware bay and river, (in three sheets,) viz:				
1. (Upper,) Coast Chart, No. 25.....	F.	25½ × 36	$\frac{1}{80,000}$	1848
2. (Middle,) Coast Chart, No. 26.....	F.	do.	do.	1848
3. (Entrance,) Coast Chart, No. 27.....	F.	do.	do.	1848
Delaware and Chesapeake bays.....	Pr.	25½ × 31	$\frac{1}{400,000}$	1855
Sea-coast Chart, No. 8; sea-coast of Delaware, Maryland, and part of Virginia.....	Pr.	20 × 28	$\frac{1}{200,000}$	1852
Sea-coast Chart, No. 9; sea-coast of Virginia and entrance to Chesapeake bay.....	Pr.	21 × 28	do.	1855
Chincoteague inlet.....	Sk.	14 × 17½	$\frac{1}{40,000}$	1852
Metompkin inlet.....	Sk.	19½ × 21½	$\frac{1}{20,000}$	1862
Wachapreague, Machipongo, and Metompkin inlets.....	Sk.	12½ × 16	$\frac{1}{40,000}$	1853
Ship and Sand Shoal inlets.....	Pr.	14 × 17	do.	1854
Chesapeake bay, (in six sheets,) viz:				
1. From head of bay to mouth of Magothy river, Coast Chart, No. 31.....	F.	30 × 37½	$\frac{1}{80,000}$	1863
2. From Magothy river to Choptank river, Coast Chart, No. 32.....	F.	30 × 37½	do.	1863
3. From Choptank river to the Potomac river, Coast Chart, No. 33.....	F.	30 × 37½	do.	1863
4. From the Potomac river to Pocomoke sound, Coast Chart, No. 34.....	F.	26 × 38	do.	1863
5. From Pocomoke sound to York river, Coast Chart, No. 35.....	F.	26 × 38	do.	1863
6. From York river to entrance, Coast Chart, No. 36.....	F.	26 × 38	do.	1863
Cherrystone inlet.....	Sk.	9 × 13	$\frac{1}{40,000}$	1853
Pungoteague creek.....	Sk.	8½ × 10½	do.	1853

Coast and Harbor Charts—Continued.

TITLE.	Class.	Size of border.	Scale.	Date of last edition.
		<i>Inches.</i>		
Mouth of Chester river	F.	14 × 17½	$\frac{1}{40,000}$	1849
Patapsco river	F.	17½ × 27½	$\frac{1}{60,000}$	1859
Annapolis harbor	F.	14 × 17½	do.	1846
Patuxent river, (lower)	Pr.	19 × 22½	do.	1859
Patuxent river, Point Judith to Nottingham	Pr.	18 × 31½	$\frac{1}{30,000}$	1860
Potómac river, (in four sheets,) viz:				
1. Entrance to Piney Point	Pr.	23 × 29½	$\frac{1}{60,000}$	1862
2. Piney Point to Lower Cedar Point	Pr.	23 × 29½	do.	1862
3. Lower Cedar Point to Indian Head	Pr.	23 × 29½	do.	1862
4. Indian Head to Little Falls bridge	Pr.	23 × 39	$\frac{1}{40,000}$	1862
Rappahannock river, (in six sheets,) viz:				
1. From Fredericksburg to near Moss Neck	F.	17 × 29	do.	1862
2. From Moss Neck to Port Royal	F.	do.	do.	1862
3. From Port Royal to Saunders's wharf	Pr.	do.	$\frac{1}{20,000}$	1862
4. From Saunders's wharf to Occupacia creek	Pr.	do.	do.	1862
5. From Occupacia creek to Deep creek	F.	do.	do.	1862
6. From entrance to Deep creek	F.	do.	do.	1862
York river, Va., (in two sheets,) viz:				
1. From King's creek to West Point	F.	17 × 23	$\frac{1}{60,000}$	1858
2. From entrance to King's creek	F.	do.	do.	1857
Pamunky and Mattaponi rivers	Sk.	14½ × 18	do.	1862
James river, (in two sheets,) viz:				
1. From Richmond to City Point	Pr.	28 × 30	$\frac{1}{40,000}$	1855
2. From entrance to City Point	Pr.	28 × 41	$\frac{1}{30,000}$	1859
Hampton Roads and Elizabeth river	Pr.	16 × 22	$\frac{1}{40,000}$	1857
Norfolk harbor	Pr.	16 × 20	$\frac{1}{10,000}$	1857
Atlantic coast, from entrance of Chesapeake bay to Ocracoke inlet	Sk.	17 × 28	$\frac{1}{400,000}$	1862

REPORT OF THE SUPERINTENDENT OF
Coast and Harbor Charts—Continued.

TITLE.	Class.	Size of border.	Scale.	Date of last edition.
North Landing river.....	F.	<i>Inches.</i> 17 × 21	$\frac{1}{40,000}$	1861
Pasquotank river.....	F.	14 × 17½	$\frac{1}{60,000}$	1850
Albemarle sound, (in one sheet)	Pr.	15½ × 22	$\frac{1}{200,000}$	1855
Albemarle sound, (in two sheets,) viz:				
1. Western part, Coast Chart, No. 40.....	F.	29½ × 31½	$\frac{1}{80,000}$	1860
2. Eastern part, Coast Chart, No. 41.....	F.	do.	do.	1860
Mouth of Roanoke river	Sk.	19 × 21	$\frac{1}{30,000}$	1863
Oregon inlet.....	Sk.	16 × 17½	$\frac{1}{20,000}$	1863
Wimble shoals	Sk.	7 × 8	$\frac{1}{80,000}$	1854
Hatteras shoals.....	Sk.	11½ × 11½	$\frac{1}{120,000}$	1850
Hatteras inlet.....	Pr.	15 × 17	$\frac{1}{20,000}$	1861
Ocracoke inlet	Pr.	14 × 14½	$\frac{1}{40,000}$	1852
Cape Lookout shoals.....	Sk.	17½ × 20½	$\frac{1}{80,000}$	1864
Beaufort harbor	F.	23 × 30	$\frac{1}{20,000}$	1857
Beaufort harbor, (new edition).....	Pr.	18½ × 19½	do.	1864
Core sound.....	Pr.	19 × 33	$\frac{1}{40,000}$	1864
New river and bar.....	Sk.	14 × 17	$\frac{1}{15,000}$	1852
Cape Fear and approaches, including the river to Wilmington, Coast Chart, No. 48.....	F.	32 × 40	$\frac{1}{80,000}$	1864
Cape Fear river and Frying Pan shoals.....	F.	26 × 30½	$\frac{1}{30,000}$	1857
Cape Fear river, from Federal Point to Wilmington.....	F.	26 × 30½	do.	1856
Winyah bay and Georgetown harbor.....	Pr.	17½ × 25½	$\frac{1}{40,000}$	1855
Winyah bay and Cape Roman shoals.....	Pr.	14 × 21½	$\frac{1}{100,000}$	1854
Sea-coast Chart, No. 14, Cape Roman to Tybee island	F.	32 × 38½	$\frac{1}{200,000}$	1857
Bull's bay.....	Pr.	17 × 23	$\frac{1}{60,000}$	1859
Charleston harbor	F.	31½ × 32	$\frac{1}{30,000}$	1864
Light-house inlet.....	Sk.	10 × 20½	$\frac{1}{20,000}$	1864
Stone inlet.....	Pr.	19½ × 21	$\frac{1}{20,000}$	1862

Coast and Harbor Charts—Continued.

TITLE.	Class.	Size of border.	Scale.	Date of last edition.
North Edisto river.....	Pr.	<i>Inches.</i> 14 × 17½	$\frac{1}{50,000}$	1862
St. Helena sound.....	Pr.	24 × 28	$\frac{1}{40,000}$	1862
Port Royal entrance, Beaufort, Chechessee, and Colleton rivers.....	Pr.	22½ × 29½	$\frac{1}{60,000}$	1862
Beaufort river and inside passage between Port Royal and St. Helena sounds.....	Pr.	24½ × 28	$\frac{1}{40,000}$	1864
Calibogue sound and Skull creek.....	Pr.	22 × 28	$\frac{1}{40,000}$ $\frac{1}{20,000}$	1862
Savannah river.....	Pr.	20 × 33	$\frac{1}{40,000}$	1862
Wassaw sound.....	Pr.	20 × 33	do.	1863
Ossabaw sound.....	F.	24 × 37	$\frac{1}{30,000}$	1860
Romerly marshes.....	Pr.	16½ × 29	$\frac{1}{10,000}$	1855
Sapelo sound.....	F.	23 × 34	$\frac{1}{30,000}$	1859
Doboy bar and inlet.....	Sk.	12 × 15	$\frac{1}{40,000}$	1855
St. Simon's sound, Brunswick harbor, and Turtle river.....	F.	19 × 29	do.	1862
St. Andrew's shoals.....	Sk.	11 × 12	$\frac{1}{60,000}$	1850
Atlantic coast, Savannah river to St. Augustine.....	Sk.	23 × 35	$\frac{1}{200,000}$	1861
St. Mary's river and Fernandina harbor.....	F.	25 × 32	$\frac{1}{20,000}$	1857
St. John's river, (in two sheets,) viz:				
1. From entrance to Brown's creek.....	F.	19½ × 23	$\frac{1}{25,000}$	1856
2. From Brown's creek to Jacksonville.....	F.	19½ × 27	do.	1856
St. Augustine harbor.....	F.	21 × 22	$\frac{1}{30,000}$	1860
Mosquito inlet.....	Sk.	7 × 8	$\frac{1}{40,000}$	1851
Cape Canaveral shoals.....	Sk.	15½ × 20	$\frac{1}{60,000}$	1850

COAST OF THE GULF OF MEXICO.

Sea-coast Chart, Key Biscayne to Pickle's reef.....	Pr.	12½ × 19	$\frac{1}{200,000}$	1856
Florida reefs, (in four sheets,) viz:				
1. From Key Biscayne to Carysfort reef, Coast Chart, No. 68.....	F.	32 × 39	$\frac{1}{80,000}$	1861
2. From the Elbow to Matcumbe key, Coast Chart, No. 69.....	F.	32 × 39	do.	1863

REPORT OF THE SUPERINTENDENT OF
Coast of the Gulf of Mexico—Continued.

TITLE.	Class.	Size of border.	Scale.	Date of last edition.
		<i>Inches.</i>		
3. From Long key to Newfound Harbor key, Coast Chart, No. 70.....	F.	32 × 39	$\frac{1}{80,000}$	1863
4. Newfound Harbor key to Boca Grande key, Coast Chart, No. 71	F.	32 × 39	do.	1859
Western end of Florida reefs, Key coast to Tortugas.....	Pr.	17½ × 28	$\frac{1}{200,000}$	1863
Beacons on Florida reefs.....	Sk.	15½ × 20	$\frac{1}{400,000}$	1860
Legaré anchorage	Pr.	22 × 22½	$\frac{1}{20,000}$	1857
Turtle harbor	Sk.	8 × 9½	$\frac{1}{40,000}$	1854
Coffin's patches	Sk.	11 × 11½	$\frac{1}{20,000}$	1854
Key West harbor.....	F.	24 × 34	$\frac{1}{50,000}$	1863
Charlotte harbor.....	Pr.	22 × 27	$\frac{1}{40,000}$	1864
Tampa bay	Sk.	17 × 21½	$\frac{1}{120,000}$	1855
Waccasassa bay.....	Pr.	18 × 18	$\frac{1}{50,000}$	1856
Cedar keys	Pr.	19½ × 26	do.	1861
Ocilla river	Sk.	10 × 13	$\frac{1}{20,000}$	1855
St. Mark's river.....	Pr.	18 × 27	$\frac{1}{30,000}$	1856
St. George's sound, western part, (embracing Apalachicola harbor).....	Pr.	23½ × 34	$\frac{1}{40,000}$	1860
St. George's sound, eastern part.....	Pr.	23 × 34	do.	1859
St. Andrew's bay.....	Pr.	17½ × 19	do.	1855
Escambia and Santa Maria de Galvaez bays	Pr.	26 × 31½	$\frac{1}{30,000}$	1861
Pensacola bay, entrance to	F.	25½ × 32	$\frac{1}{20,000}$	1859
Sea-coast Chart, No. 26; part of Alabama and Mississippi.....	Pr.	20 × 27	$\frac{1}{200,000}$	1857
Mobile bay, entrance to.....	F.	19 × 28½	$\frac{1}{40,000}$	1851
Mobile bay, Coast Chart, No. 90.....	F.	29 × 38	$\frac{1}{80,000}$	1856
Mississippi sound, eastern part, Coast Chart, No. 91.....	F.	31½ × 40½	do.	1860
Mississippi sound, western part, Coast Chart, No. 92.....	F.	32 × 41½	do.	1860
Horn Island pass.....	Pr.	12 × 16	$\frac{1}{40,000}$	1853
Pascagoula River entrance.....	Sk.	10½ × 13	$\frac{1}{20,000}$	1853

THE UNITED STATES COAST SURVEY.

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Coast of the Gulf of Mexico—Continued.

TITLE.	Class.	Size of border.	Scale.	Date of last edition.
Cut and Ship Island harbors	F.	<i>Inches.</i> 17 × 34	$\frac{1}{40,000}$	1850
Biloxi bay	Pr.	14 × 17	do.	1858
Pass Christian harbor	Sk.	9 × 11	do.	1851
Pass à l'Outre, Mississippi delta	Sk.	18 × 21	$\frac{1}{20,000}$	1860
The delta of the Mississippi, reconnaissances of the passes	Sk.	13½ × 21	$\frac{1}{60,000}$	1852
Southwest pass of the Mississippi	Sk.	15 × 19	$\frac{1}{20,000}$	1862
Barataria Bay entrance	Sk.	14 × 17½	$\frac{1}{30,000}$	1853
Pass Fourchon	Sk.	7 × 10	$\frac{1}{10,000}$	1854
Timballier Bay entrance	Sk.	11 × 16½	$\frac{1}{20,000}$	1853
Ship Island shoal	Sk.	16 × 17½	$\frac{1}{40,000}$	1853
Atchafalaya bay	Pr.	26½ × 31	$\frac{1}{50,000}$	1858
Vermillion bay and Calcasieu river	Sk.	11 × 13	$\frac{1}{40,000}$ $\frac{1}{30,000}$	1855
Sabine pass	Sk.	9 × 11	$\frac{1}{40,000}$	1853
Galveston entrance	F.	14 × 17	do.	1856
Sea-coast Chart, No. 30, Galveston bay	Pr.	17 × 20	$\frac{1}{200,000}$	1855
Sea-coast Chart, No. 31, Galveston bay to Matagorda bay	Pr.	32 × 36½	do.	1857
Galveston bay to Oyster bay, Coast Chart, No. 106	Pr.	32½ × 40	$\frac{1}{80,000}$	1858
Oyster bay to Matagorda bay, Coast Chart, No. 107	Pr.	32 × 40	do.	1858
San Luis pass	Pr.	14 × 17	$\frac{1}{20,000}$	1853
Brazos River entrance	Pr.	15½ × 18	$\frac{1}{10,000}$	1858
Matagorda and Lavaca bays	Pr.	25 × 42	$\frac{1}{40,000}$	1857
Coast of Texas between Matagorda and Corpus Christi—reconnaissance	Pr.	20 × 24	$\frac{1}{1,200,000}$	1858
Aransas pass	Sk.	9½ × 12½	$\frac{1}{20,000}$	1853
Rio Grande entrance	Pr.	14 × 16	do.	1854

PACIFIC COAST.

TITLE.	Class.	Size of border.	Scale.	Date of last edition.
Western coast of the United States, reconnaissance of, (in three sheets,) viz:				
1. From San Diego to San Francisco.....	Pr.	<i>Inches.</i> 22 × 23	$\frac{1}{1,200,000}$	1853
2. From San Francisco to Umpqua river.....	Pr.	22½ × 25	do.	1854
3. From Umpqua river to the boundary.....	Pr.	do.	do.	1855
San Diego bay	F.	20 × 27	$\frac{1}{40,000}$	1859
Cortez Bank.....	Sk.	13½ × 18½	$\frac{1}{80,000}$	1856
San Clemente, Prisoners' and Cuyler's harbors	Sk.	14 × 17½	$\frac{1}{20,000}$	1852
Anacapa island and eastern part of Santa Cruz island.....	Pr.	9½ × 26½	$\frac{1}{30,000}$	1856
San Pedro anchorage and vicinity of Santa Barbara.....	Sk.	8 × 15	$\frac{1}{20,000}$ $\frac{1}{40,000}$	1855
San Pedro harbor.....	Pr.	12½ × 16	$\frac{1}{30,000}$	1852
Santa Barbara	Sk.	14 × 17	$\frac{1}{20,000}$	1853
Eastern entrance to Santa Barbara channel.....	Pr.	16½ × 23½	$\frac{1}{80,000}$	1857
Point Conception.....	Sk.	7 × 7½	$\frac{1}{40,000}$	1850
Santa Cruz, San Simeon, Coxo, and San Luis Obispo harbors—reconnaissance	Sk.	13½ × 17½	$\frac{1}{20,000}$	1852
Point Pinos.....	Sk.	7½ × 9	do.	1851
Pacific coast, from Point Pinos to Bodega head.....	Pr.	28 × 39	$\frac{1}{200,000}$	1862
Monterey harbor.....	Pr.	12 × 13	$\frac{1}{40,000}$	1852
Monterey bay.....	Pr.	20½ × 31	$\frac{1}{60,000}$	1857
Santa Cruz and Año Nuevo harbors.....	Pr.	12½ × 12½	$\frac{1}{40,000}$	1854
Half-Moon bay	Pr.	18½ × 20	$\frac{1}{20,000}$	1863
San Francisco bay entrance	F.	24 × 39	$\frac{1}{50,000}$	1859
San Pablo bay.....	F.	24 × 39	do.	1860
Petaluma and Napa creeks	Pr.	21 × 30	$\frac{1}{30,000}$	1861
Mare Island straits	F.	14½ × 18	do.	1863
San Francisco bay, upper part.....	Pr.	27 × 36	$\frac{1}{50,000}$	1862

Pacific Coast—Continued.

TITLE.	Class.	Size of border.	Scale.	Date of last edition.
City of San Francisco	Pr.	<i>Inches.</i> 24 × 35	$\frac{1}{10,000}$	1857
Point Reyes and Drake's bay	Sk.	9 × 10	$\frac{1}{40,000}$	1855
Drake's bay	Pr.	19½ × 30	do.	1860
Bodega bay	Pr.	13 × 17	$\frac{1}{30,000}$	1862
Tomales bay	Pr.	15½ × 24½	do.	1861
Humboldt bay	Pr.	14 × 17½	do.	1858
Trinidad bay	Sk.	8½ × 10½	$\frac{1}{20,000}$	1851
Crescent City harbor	F.	12 × 16	do.	1859
Port Orford, Shelter cove, Mendocino City, and Crescent City harbor	Sk.	14 × 18	do.	1854
Coquille River entrance	Pr.	14½ × 20½	$\frac{1}{10,000}$	1861
Koos bay	F.	15 × 18	$\frac{1}{20,000}$	1861
Umquah River entrance	Pr.	13 × 17	do.	1854
Columbia River entrance	Pr.	13½ × 14	$\frac{1}{40,000}$	1854
Cape Hancock	Sk.	7 × 8	$\frac{1}{20,000}$	1851
Shoalwater bay	Pr.	17 × 25	$\frac{1}{20,000}$	1856
Gray's harbor	Pr.	16½ × 17	$\frac{1}{40,000}$	1862
Cape Flattery and Nec-ah harbors	F.	14 × 17	do.	1853
False Dungeness and New Dungeness	Sk.	10 × 23	$\left\{ \begin{array}{l} \frac{1}{30,000} \\ \frac{1}{40,000} \end{array} \right\}$	1853 1856
Port Townshend	Sk.	11½ × 14½	$\frac{1}{40,000}$	1858
Smith's or Blunt's island	Sk.	6½ × 9½	$\frac{1}{20,000}$	1854
Port Ludlow	Pr.	11 × 14½	do.	1856
Port Gamble	Pr.	16 × 23	do.	1858
Duwamish bay and Seattle harbor	Sk.	8 × 10	$\frac{1}{40,000}$	1854
Steilacoom harbor	Sk.	12 × 16	$\frac{1}{30,000}$	1856
Olympia harbor	Sk.	10½ × 12½	$\frac{1}{20,000}$	1856

Pacific Coast—Continued.

TITLE.	Class.	Size of border.	Scale.	Date of last edition.
Washington sound.....	Pr.	<i>Inches.</i> 25½ × 27	$\frac{1}{200,000}$	1863
Blakely harbor	Sk.	11½ × 15½	$\frac{1}{10,000}$	1856
Bellingham bay	Sk.	14 × 16½	$\frac{1}{40,000}$	1856
Semi-ah-moo bay	Sk.	11½ × 16½	$\frac{1}{30,000}$	1858

ELECTROTYPE AND PHOTOGRAPH DIVISION.—This branch of the work has continued under the direction of Mr. George Mathiot. During the first half of the year he was assisted by Mr. A. Zumbrock, and since then he has performed the work of the division without an assistant.

The electrotype process has been applied, as heretofore, to the duplication of the engraved plates and the compounding of separately engraved parts of plates. Thirty-two plates, of which seventeen were "altos" and fifteen "bassos," were made during the year.

The use of photography for reducing the original surveys to the publication scales, and for duplicating drawings for other departments of the government, has been continued. During the year twenty-eight glass "positives," eighty-seven glass "negatives," and seven hundred and forty-six paper prints, mostly of large size, have been made from seventy-eight original drawings. The appended tables state in detail the work performed in this division:

Table of electrotypes made during the year ending October 1, 1864.

ALTOS.	BASSOS.
Rappahannock river, sheet No. 2.	Atlantic coast, sheet No. 2.
Atlantic coast, sheet No. 2.	Rappahannock river, sheet No. 1.
San Francisco bay.	Key West harbor.
Atlantic coast, sheet No. 3.	Atlantic coast, sheet No. 3.
Chesapeake bay, sheet No. 6.	Rappahannock river, sheet No. 2.
Coast Chart, No. 4.	Chesapeake bay, sheet No. 6, (bis.)
Saint John's river.	Coast Chart, No. 10.
Coast Chart, No. 10.	San Francisco bay.
Atlantic coast, sheet No. 4.	Chesapeake bay, sheet No. 5.
Chesapeake bay, sheet No. 5.	Atlantic coast, sheet No. 4.
James river, sheet No. 2.	Chesapeake bay, sheet No. 3.
Nantucket shoals.	York river, (entrance.)
Chesapeake bay, sheet No. 3.	Boston harbor.
Nantucket shoals, (new edition.)	Nantucket shoals.
Gulf coast, (east half.)	Saint John's river.
Gulf coast, (west half.)	
Chesapeake bay, sheet No. 4.	

Objects photographed.	Positives.	Negatives.	Prints.
Drawing of a rebel ram		6	49
Six drawings of rebel works at Vicksburg		1	5
Drawing, map of Rockbridge county, Virginia			6, 2 in. to 1 mile
Twelve maps of Washington and vicinity		1	179, 2 in. to 1 mile
Drawings, specimens of topographical drawing		1	9
Tracing, Guyot's mountains of Tennessee			4
Drawing of Grand Gulf, Mississippi		2	24
Drawing showing the organization of the Sanitary Commission		1	4
Maps, Georgia from Atlanta to Augusta		1	4
Two maps of western South Carolina and Georgia		2	8
Tracing, map of Rockland harbor	2 of 1-20,000		
Road map showing the approaches to Washington, D. C.		6	42
Coast chart No. 10, 13 tracings	6 of 1-80,000	23	26 of 1-80,000
Three tracings for chart Tomales bay, California	3 of 1-30,000		
Tracing, Ossabaw sound, Georgia	1 of 1-10,000	1 of 1-10,000	2 of 1-10,000
Drawing of proposed sailing compasses for the monitors		2	12, $\frac{1}{2}$ of original
Three tracings for coast chart No. 11	1 of 1-80,000	2 of 1-80,000	4 of 1-80,000
Tracing part of Boston harbor		1	2 of 1-40,000
Two tracings for map of Henrico county, Virginia		1	120, 2 in. to 1 mile
Plane-table sheet of the city of Richmond	1 of 1-10,000		
Views of pontoon bridges			38
Map of Cumberland, Maryland		1	5, reduced one-half
Sketch showing the relative positions of coast charts Nos. 68, 69, 70, 71 ..	1	1	2, 1-10 of original
Drawing, map of Appomatox river, from City Point to Petersburg ..		1	18 of 1-20,000
Plans of the battles of Saline cross-roads		1	6, $\frac{1}{2}$ of original
Maps of the survey of the Pacific railroad, California		5	42
Maps of the James river, from City Point to Richmond		2	42
Projects to prevent counterfeiting treasury notes by photography ..		5	10
Two plane-table sheets of the Appomatox river		2	8
Maps of Carroll and Howard counties, Maryland			17
Tracing, map of the Mississippi river from Rodney to Sargent's bend ..	3	2	
Drawing showing compass variations on the steamer Roanoke		1	2
Six maps of the northwest boundary of the United States		6	42
Four tracings for coast chart No. 53			8 of 1-40,000
One tracing for coast chart No. 8	1	1	2 of 1-80,000
One tracing for coast chart No. 47	1 of 1-80,000	2	2 of 1-80,000
Three tracings for coast chart No. 54	6 of 1-80,000	2	4 of 1-10,000
One tracing for chart of Bodega bay, California	1 of 1-30,000	1	1 of 1-30,000
One tracing for chart of Casco bay	1	1	1 of 1-10,000
Three tracings for chart of Hudson river	6 of 1-60,000	3	3 of 1-60,000
Three tracings for chart of Sheepscot river	4 of 1-80,000		

LITHOGRAPHING DIVISION.—The details of work in this division were directed until the 1st of June by *Professor F. A. P. Barnard*. On his acceptance of the presidency of Columbia College, they were devolved, together with the supervision of the map printing, upon *Mr. W. W. Cooper*, in addition to usual duties, of which he still remains in charge, in the office of the superintendent.

When this section of the office was organized, the outfit for lithographing was adapted merely to the occasion, connected with increase of the navy, which very largely raised the demand for copies of coast charts, and particularly of such as were needed in blockade duty. In the course of the war, however, much material of public interest came in, furnished in part by our topographers associated for duty with the armies, and partly by the military engineers. To make such matter further available for the public service, facilities for publication have been added from time to time, and data of importance can now be embodied at once, either with some of the military maps already provided in the division or prepared in a separate form, as may be most desirable. The engravings on stone being, moreover, of a uniform scale for a very large part of the southern States, any limits for a special map may be chosen at pleasure, and a sheet issued promptly when needed in prospective military movements. This remark applies to the area of all the States in rebellion east of the Mississippi river, excepting the back districts of North and South Carolina, and the neutral part of Tennessee and to southern Florida, in which no military movements have taken place.

Much of the effectiveness of style in the maps already published, and their completeness in respect of attainable data, are due to the intelligent interest given to the work by *Professor Barnard* while he was temporarily in charge of the division.

The special maps drawn this year by *Mr. A. Lindenkohl*, and by *Mr. H. Lindenkohl*, previous to the end of August, when he retired from the office, comprise the greater part of the States of Virginia, Georgia, Alabama, Mississippi, and Florida, and parts of North and South Carolina and of Tennessee. Divided and recombined in various ways, these drawings have all been published, to serve as military maps, and as such they have been in requisition with the two armies under command of Lieutenant General Grant and Major General Sherman.

The lithographic engraving has been done, as heretofore, by *Mr. C. G. Krebs*, and, in addition, much of his time and that of *Mr. H. Lindenkohl* has been given to the adjustment of supplementary material in the extension or correction of hydrographic charts, and in the revision of military maps, with a view of combining the latest information in successive editions. In the beginning of the present working year *Mr. Edward Molitor* was temporarily attached to the division as engraver, and also for a short period in September last.

Transfers have been made during the year from fifty-four of the engraved copper plates of the office, and from sixty-four lithographic engravings, exclusive of thirty-seven offsets, for printing in color. The transfers from copper and thirty-five of the others were made by *Mr. Arch'd Brown*, the remainder by *Mr. James Ruhl*.

Several of our hydrographic charts have been issued from the division with distinctive color to mark the parts covered by shoal water. This expedient promises well as a substitute for the engraved "sanding," and is specially adapted to the ready publication of charts in their complete form.

The military maps before referred to have been prepared for color-printing, and range from one to as many as five colors on a single sheet. The statistics of these and of the printing from copper plate transfers will be stated under the next head.

The titles of the maps drawn and engraved on stone during the present year are given in a summary of office-work in the introductory part of the Superintendent's report.

MAP PRINTING.—In the lithographic division, seventeen thousand four hundred and eighty-nine copies of the hydrographic charts of the Coast Survey have been printed from transfers during the year on two presses by *Mr. Brown* and *Mr. Ruhl*. The copper plate press of the office, worked by *Mr. John Rutherford*, has furnished ten thousand two hundred and seventy-eight copies, exclusive of fourteen hundred and ninety-two chart proofs taken for the engraving division; and fifteen thousand eight hundred and five copies of hydrographic charts were printed by the transfer process out of the office.

The aggregate of charts printed during the year for distribution is forty-three thousand five hundred and seventy-two.

In the lithographic section twelve thousand one hundred and twenty-five copies of military maps have been printed. Most of the sheets being in colors, twenty-seven thousand two hundred and ninety-five impressions were required. Nearly nine hundred copies of maps so produced were of five colors; eight hundred of four colors; more than two thousand were of three colors; and over five thousand copies were issued in two colors.

Including six thousand sheets of various kinds of circulars for official use, the two lithographic presses have given an aggregate of nearly fifty-one thousand impressions during the year.

In order to keep up with the demand for war maps, it has been necessary in several instances to send to other printing offices for the press-work, transfers from our lithographic engravings. The number of sheets received in that way during the year was ten thousand two hundred. These added to the number printed in the section make a total of twenty-two thousand three hundred and twenty-five copies, and, with the hydrographic charts, an aggregate of sixty-five thousand eight hundred and ninety-seven sheets, exclusive of proofs and circulars, of which the number printed was upward of seven thousand.

Distribution of maps and annual reports.—The charge of the map-room has continued with *Mr. M. T. Johnstone*, and, as will be seen by his returns, a larger distribution has been made during the present year than in any preceding one.

The total number of sheets printed during the year has been sixty-five thousand eight hundred and ninety-seven, (65,897.) Of this number, there have been issued from the office fifty-three thousand seven hundred copies, (53,700,) of which thirty-six thousand six hundred and ninety-seven (36,697) have been hydrographic charts, distributed as follows:

To the navy	23, 159
To sea captains and pilots employed in government service	2, 788
To military officers	2, 424
By sale	4, 598
Miscellaneous	4, 728
Total	<u>36, 697</u>

Exclusive of these, upward of seventeen thousand sheets of military maps have been issued from the office by *Mr. V. E. King*.

Of the charts intended for the use of the navy, 19,720 have been distributed through the Naval Observatory.

Those classed under the head "miscellaneous" include those sent to the Light-house Board and persons in their service. A large number have been called for by quartermasters and various revenue officers, and the selected presentations to various foreign vessels-of-war have been many more than usual. Under this head are also included the charts sent to the assistants of the Coast Survey engaged in the various naval expeditions fitted out during the year; also those called for by members of Congress.

The map-room is now much resorted to by the masters of vessels chartered by the government, as also by masters of private vessels, to obtain information as to harbors and parts of the coast they expect to visit. They bear a willing testimony to the accuracy of the charts, and their consequent reliance on them is great, which is shown by the annual increasing sale of those charts.

The distribution of the reports of the superintendent has been small, which is accounted for by the circumstance that last year copies of all the reports then on hand were supplied to the various public libraries, universities, colleges, and other public institutions and associations in the loyal States, while the printed copies of the report of 1862 were not received in time to be included in the present return, except to a very small extent. These reports are coming into considerable demand by masters of vessels, who appear to prize them much. The copies of those years of which there is a considerable number on hand have been freely distributed among this class of men, who, as a class, are more than usually intelligent.

There remains on hand an aggregate number of 14,165 copies of the reports of all years. The stock of some of the early reports, as was observed last year, is now nearly exhausted. The following is a statement of the distribution of these reports during the year:

Distribution made during the year of reports of the United States Coast Survey for the years 1851, 1852, 1853, 1854, 1855, 1856, 1857, 1858, 1859, 1860, 1861, and 1862.

Names of States, &c.	Report of 1851.		Report of 1852.		Report of 1853.		Report of 1854.		Report of 1855.		Report of 1856.		Report of 1857.		Report of 1858.		Report of 1859.		Report of 1860.		Report of 1861.		Report of 1862.		Total number distributed.
	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	
Maine					1	1					1	1			2		2	1	41	1	24	2	1		78
New Hampshire					1		1												13		12				27
Massachusetts					3						2				1		7		44		35		1		93
Rhode Island																		3		1					4
Connecticut					1						2				1		3		12		19				39
New York			2		2	1	2		2		4	1	1		1		3		28	2	49	2	3		103
New Jersey	1		1									1			3		2		6	1	11	1			28
Pennsylvania							1		1		3		1		3		5		19		42		8		83
Delaware																		2							2
Maryland	1		2		2		1		3		4		3		2		2		3		9				32
District of Columbia	2		4		6		3		2		3		4		2		6		21		45		5		103
South Carolina																							1		1
Louisiana																			1		1		1		3
Ohio															60		61		62		74				257
Kentucky																					1				1
Tennessee											1						1								2
Indiana					1						1		2		2		6		6		10				28
Illinois																	1		1		5				7
Michigan																			1		2				3
Iowa															2		2		1		4				9
Minnesota															1		1		1		1				4
California																					1				1
Oregon																					1				1
Members of Congress			3		9		3				10		1		4		10		10		15				65
Officers of the navy															1		4		2		5		1		13
Officers of the army					1				1		2				2		1		3		4		2		16
Executive departments			1		2		1		1		1		2		2		1		2		9				22
Coast Survey Office assistants	1		1		12		2		2		3		2		3		2		12		31		86		157
Foreign	3		3		3		3		3		3		5		5		7		7		315		14		371
Total	8		17		44	2	17		16		41	2	22		97		127	1	301	4	726	5	123		1,553

Folding-room.—The work of backing with muslin the sheets intended for use by the plane-table and hydrographic parties has been performed by *Mr. G. W. Francis*. He has also backed with paper the sailing charts intended for distribution from the office for the use of the navy.

Instrument shop.—The charge of the shop has remained with *Mr. T. J. Hunt*, who is assisted by one workman and three apprentices—the least force that has for years past carried on the necessary operations. As a consequence, the work has been almost exclusively confined to the repairing of instruments used in the field. The finished work of the year consists of six metre scales, six 7-inch German-silver protractors, one prismatic compass, three stands for theodolites, and one pair of magnets. The repair of instruments during the year consists, in part, of twenty-seven theodolites, twenty plane-tables, nine reconnoitring telescopes, six levelling instruments, sixteen sextants, seven prismatic compasses, six marine glasses, four 3-arm protractors, six heliotropes, four surveyors' compasses, twelve metre chains, two hair frames, one astronomical eye-piece, two pantographs, one large astronomical telescope, one tide-gauge, one camera, one astronomical clock, two telegraphic instruments, and two spring governors; in addition to which a great variety of miscellaneous work has been accomplished for office and field purposes.

Carpenter shop.—*Mr. A. Yeatman* still remains in charge of the shop, and is assisted by one workman. During the year the work has included the construction of a large camera, with stands and rail-tracks; two large first-class map cases for the Navy Department; fifteen map and paper cases for the office; thirty-one cases for instruments, such as theodolites, plane-table, &c.; nine new stands for theodolites, plane-table, &c.; two levelling rods; seven plane-table boards; fourteen drawing-boards; seventeen wooden pans and frames for photographic purposes; twelve frames for electrotype purposes; one stand for a large portfolio; rollers and cornices for twenty-two maps; eighty-four tin cases for holding original sheets of the survey have been printed and numbered; and one hundred and twenty-three rough packing boxes for the transportation of instruments and records. In addition to the above, the office buildings and wood-work of instruments have been kept in repair.

APPENDIX No. 11.

REPORT OF PROFESSOR BENJAMIN PEIRCE, OF HARVARD, ON COMPUTATIONS FOR LONGITUDE FROM OCCULTATIONS OF THE PLEIADES.

CAMBRIDGE, December 5, 1864.

DEAR SIR: I have the honor to report to you the progress of the computations of the occultations of the Pleiades up to the present date. The group of observations from 1838 to 1842 is wholly under my special charge, with the assistance of Mr. Charles S. Peirce. The computations of the equations of condition are all made for the first time, and the duplicate computation is also almost completed. The preliminary examination of these equations show the most extraordinary agreement of all the observations of each occultation made at good observatories and by experienced observers, and fully justifies the expectations of their value. The agreement, with the tables of Hansen, is also such as to confirm the anticipations of the excellence of those tables; but there are some undoubted discrepancies with observation, which seem to indicate recondite sources of error in the tables, which it may require much time and thought to investigate. Thus the occultations of March 19, 1839, clearly demonstrate an error of the tables of about five seconds of arc. It is easy enough to see what this is not: it is not error of semi-diameter, or of parallax, or of elliptic elements, or of the coefficients of the parallactic equation; but what it is is still a mystery.

The last group of the Pleiades occultations has been put into the hands of computers in the office at Washington by Mr. Schott, under my directions, and is rapidly advancing towards completion.

Very respectfully,

BENJAMIN PEIRCE.

A. D. BACHE, LL.D.,

Superintendent United States Coast Survey.

APPENDIX No. 12.

REPORT OF DR. B. A. GOULD ON THE RESULTS OF COMPUTATIONS FOR LONGITUDE BY THE TELEGRAPHIC METHOD.

CAMBRIDGE, *November*, 1864.

DEAR SIR: In presenting my annual report I have the pleasure of stating that all the determinations of longitude made under my directions have now been rediscussed, with the aid of the standard Right Ascensions of the survey, and with the values for instrument constants which a long series of years has enabled us to deduce, and which may properly be regarded as the best attainable.

Three more determinations may be definitely adopted, viz:

	<i>m. s.</i>
Seaton—Raleigh	6 32.93
Raleigh—Columbia	9 35.86
Roslyn—Wilmington	2 11.32
And combining these with the result given in my last report—	
Wilmington—Columbia	12 21.72

we find:

Seaton—Wilmington	3 47.07
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By the aid of this last value, all the longitudes measured telegraphically in the southern States may be referred to the Seaton station, in Washington, which has, from the beginning, been adopted as the zero point of the telegraphic determinations of the Coast Survey. The longitudes of the respective station points west of the Seaton station thus become:

	<i>m. s.</i>
Petersburg, (Roslyn)	1 35.75
Wilmington, North Carolina	3 47.07
Raleigh	6 32.93
Columbia	16 08.79
Macon	26 30.97
Appalachicola	31 57.33
Eufaula	32 33.99
Montgomery	37 12.55
Pensacola	40 50.79
Lower Peach Tree	42 11.32
Mobile	44 11.07
New Orleans	52 18.23

The measurement Seaton—Roslyn, combined with Roslyn—Wilmington, gives a second and independent determination for the longitude of the last-named station, and illustrates the precision attainable by the telegraphic method. But, close as this accordance already is, I propose subjecting the Seaton—Roslyn determination to a new discussion with the more accurate data now at our disposal before investigating the degree of accordance and the sources of discrepancy. This measurement, and that of Charleston from Raleigh, which is now essentially computed, and needs only the labor of a few weeks for the attainment of a definite result, complete the series of telegraphic determinations, for which adequate materials exist.

A new determination of the difference of longitude between the station points at Washington and New York appears to me highly desirable, and I would urge its importance upon your attention. The obstacles which the war has interposed for the last three years promise soon to be removed, and there may be risk in long delaying this much-needed measurement. Our best value at present depends on the determinations Washington—Philadelphia and Philadelphia—Jersey City, combined with a geodetic reference of the station point in Jersey City to that in New York; and as these were among the earliest telegraphic determinations ever made by present methods, many of the precautions and refinements now in use were naturally omitted.

The experience of another year has seemed to justify the reliance which we have placed upon the accuracy of our standard Right Ascensions. I have known of no reference to them in other terms than commendation from any quarter, with a single exception, to which I will presently refer. The corresponding declinations are still, as described in my last report, in the form of equations of condition, which can readily

be solved at any time; but, except in a couple of special cases, the solutions have not been executed, owing to my desire to improve the numerical values for some of the systematic differences, (adopted for reference of the places given to the equinoctial points of Argelander's *Positiones Mediae*;) and also to the wish that as many recent determinations may be incorporated as possible.

A very considerable amount of labor has been expended upon the first-named object during the year, especially as bearing upon the declinations of southern stars, and I have been gratified by finding it possible to obtain very satisfactory formulae for the differences between the catalogue places of the St. Helena and Cape of Good Hope observations and those of Pond and Argelander. Before the expiration of another year I hope to deduce the final results of this discussion of the declinations, and also to subject the list of Right Ascensions to a new scrutiny by means of observations accumulated since the last computation.

The exceptional instance to which I alluded is an astronomer of the Cambridge observatory, who has sharply criticised the values obtained for two of the stars— δ 1 (H ϵ v.) Cephei and Polaris—in two communications, published in the proceedings of the American Academy, of Boston, and reissued in pamphlet form from the observatory. It will be remembered that in the entire list of 176 stars the four polars were the only ones which were not subjected to a new discussion in 1861; but that the positions for these were taken from the investigations made in 1855-'6, and published in volume VI of the *Astronomical Journal*. The stars whose places, or rather the determination of whose places, have now been criticised and called in question are two of these polars, for which I was prepared to find some discordance manifested after the lapse of nine years from the latest observations employed; but after such examination as I have yet been able to give, I have the pleasure of reporting that my reliance on the results previously deduced has been much strengthened. Moreover, as the error ascribed to the resultant places of the Coast Survey list is not of an order of magnitude recognizable by any transit instrument existing, I have felt warranted in leaving these criticisms unanswered.

Additional investigations have been made during the year concerning the diurnal motions of astronomical instruments in azimuth. The results have been confirmatory of the inferences reported two years ago as to the existence and approximate regularity of the azimuthal fluctuations. I cannot but believe that in all observations, however firm and deep the foundations, and however well mounted the instruments may be, this diurnal oscillation must be brought into account, if the best attainable Right Ascensions are desired.

A value for the azimuth correction deduced from observations made early in the evening will rarely be found applicable to observations later in the night, and *vice versa*.

During the year I have been aided by Messrs. Cleveland Abbe and William H. Palmer, to whom my best acknowledgments are due for valuable and constant assistance. Mr. Abbe, who had given efficient and essential aid for four years, was compelled by ill health to leave my party at the end of July, and the recent resignation of Mr. Palmer from the Coast Survey to enter the naval service leaves a vacancy which will not easily be filled.

I am, very respectfully and truly, your obedient servant,

B. A. GOULD.

Professor A. D. BACHE,

Superintendent United States Coast Survey.

APPENDIX No. 13.

THE PROBLEM OF DETERMINING A POSITION BY ANGLES OBSERVED UPON A NUMBER OF GIVEN STATIONS. SOLUTION OF GAUSS, WITH EXAMPLE, COMMUNICATED BY CHARLES A. SCHOTT, ASSISTANT COAST SURVEY.

The problem of determining a position by angles observed upon three given stations being commonly known as the *three-point problem*, the more general form of the same, where the angles, measured at the sought station between any number of given points, fix its position, may be designated as the *n-point problem*.

According to Gerling,* the solution of this problem was communicated to him by Gauss in 1810; it is given in a somewhat different shape in the *Astronomische Nachrichten*;† there is also a solution by Bessel.‡

* *Pothenotsche Aufgabe, in practischer Beziehung.* von C. L. Gerling, Marburg, 1840.

† *Anwendung der Wahrscheinlichkeitsrechnung auf eine Aufgabe der practischen Geometrie*, vol. i, p. 84.

‡ *Zach's Monatliche Correspondenz*, 1813, vol. xxvii, p. 222.

The method given below is prepared (a free translation) from Gerling's small work entitled "Pothénot's Problem," or three-point problem, as it is usually called. The practical treatment of this useful problem is given in most standard works on geodesy; this is not the case, however, with the problem when more than three points are given and horizontal angles are measured between them at a station, the position of which is to be determined from these measures. It obviously involves the indirect treatment by the method of least squares; the solution is given here for convenience of reference.

Let

$P_1 P_2 P_3 \dots$ the given points in the order of their azimuths as they appear from the unknown point P.

$x_1 x_2 x_3 \dots$ } their rectangular co-ordinates, those of P being X and Y.
 $y_1 y_2 y_3 \dots$ }

$r_1 r_2 r_3 \dots$ the distances of P from the points $P_1 P_2 P_3 \dots$

$a_1 a_2 a_3 \dots$ the angles which these directions make with the axis of x, which axis of co-ordinates is arbitrary.

$o_1 o_2 o_3 \dots$ the observed angles at P, counted from the initial direction, PP_1 .

Hence, $a_2 - a_1 = o_2$, $a_3 - a_1 = o_3$, etc.,

and supposing x and y approximate values of X and Y, we have, $x + dx = X$, $y + dy = Y$, $x_1 - x = r_1 \cos a_1$, $x_2 - x = r_2 \cos a_2$, $x_3 - x = r_3 \cos a_3$, etc., $y_1 - y = r_1 \sin a_1$, $y_2 - y = r_2 \sin a_2$, $y_3 - y = r_3 \sin a_3$, etc. We have to express the corrections da_1, da_2, da_3, \dots , to the computed angles a_1, a_2, a_3, \dots , in terms of dx and dy , which corrections should be small, but the process may be repeated if their values should be found too great.

Differentiating the expression $\tan a_1 = \frac{y_1 - y}{x_1 - x}$, we have, $da_1 = \left(-\frac{dy}{x_1 - x} + (y_1 - y) \frac{dx}{(x_1 - x)^2} \right) \cos a_1^2$;

$$\text{or, } da_1 = \frac{\sin a_1}{r_1} dx - \frac{\cos a_1}{r_1} dy,$$

$$da_2 = \frac{\sin a_2}{r_2} dx - \frac{\cos a_2}{r_2} dy, \text{ etc.}$$

If we wish to express da in seconds, we multiply the right-hand term by radius reduced to seconds, (206264.8.) The approximate values x and y can either be obtained by careful plotting, for which purpose the observed angles at P are drawn upon a piece of transparent paper, which is shifted on the projection until every direction intersects its corresponding point, the position of P may then be marked and the co-ordinates measured;* or, any three points may be selected, (picking out those giving the best conditions,) and x and y found by computation, according to the ordinary formulæ of the three-point problem.

The coefficients of dx and dy can be found either by direct computation from the above expressions, or by the use of the logarithmic differences.

With the assumed values for the position of P, we therefore compute the above co-efficients and compare the computed and observed angles, the differences will form the absolute terms of our conditional equations. The two normal equations are next established and solved, and the resulting values of dx and dy applied to x and y .

If desirable we may also compute the individual errors of the observations.

To illustrate the method, I select an example from my geodetic survey, executed in and near the District of Columbia for military purposes in the winter and spring of 1863, where this kind of survey was frequently employed as both cheap and expeditious; no special signals were erected. The chief purpose was to measure a series of heights by means of measures of zenith distance, the horizontal distances required therefore only to be approximately known. Should the angles measured at the station P contain conditions, such as result from sum-angles or from closing the horizon, we suppose them adjusted by least squares† before entering on the present problem.

Given the following rectangular co-ordinates of six known stations, and the observed angles at the station which is to be determined relatively to them.‡

* For our in-shore hydrographic survey the three-point problem is almost exclusively used, the angles at the end of each sounding line are measured by a sextant, and the plotting is done mechanically by means of a three-armed brass protractor or tracing paper.

† See on this subject Coast Survey Report of 1854, pp. 70*—79*.

‡ One of the co-ordinates of an outside point, and the approximately measured angle to that point, I have changed to admit of its introduction here, merely for the sake of a more complete example.

<i>m.</i>	<i>m.</i>	<i>o</i> <i>i</i> <i>u</i>
$x_1 = +1845.0.$	$y_1 = +5534.0.$	$o_2 = 61 \ 12 \ 10$
$x_2 = +1485.0.$	$y_2 = +2486.7.$	$o_3 = 97 \ 48 \ 27$
$x_3 = 0.0.$	$y_3 = 0.0.$	$o_4 = 195 \ 55 \ 56$
$x_4 = +4418.2.$	$y_4 = +1416.7.$	$o_5 = 205 \ 35 \ 04$
$x_5 = +6163.8.$	$y_5 = +398.1.$	$o_6 = 215 \ 53 \ 44$
$x_6 = +5810.6.$	$y_6 = +1255.7.$	

For an approximate position of P we found from the graphical process, $x = +3448$ metres, and $y = +2440$ metres, and in order to illustrate the numerical process by logarithmic differences, we will select three of the above points, and compute dx and dy to obtain a closer value for x and y for our final solution. With the points $P_1 P_3 P_6$, we compute as follows:

	<i>log's.</i>
$y_1 - y = +3094.0 - dy.$	3.49052 - 14.0 <i>dy.</i>
$x_1 - x = -1603.0 - dx.$	3.20493 _n + 27.1 <i>dx.</i>
$a_1 = 117^\circ \ 23' \ 19'' + 52.5dx + 27.1dy.$	0.28559 _n - 27.1 <i>dx</i> - 14.0 <i>dy.</i>
$y_3 - y = -2440.0 - dy.$	3.38739 _n + 17.8 <i>dy.</i>
$x_3 - x = -3448.0 - dx.$	3.53757 _n + 12.6 <i>dx.</i>
$a_3 = 215^\circ \ 17' \ 07'' - 28.2dx + 40.0dy.$	9.84982 - 12.6 <i>dx</i> + 17.8 <i>dy.</i>
$y_6 - y = -1184.3 - dy.$	3.07346 _n + 36.7 <i>dy.</i>
$x_6 - x = +2362.6 - dx.$	3.37339 - 18.4 <i>dx.</i>
$a_6 = 333^\circ \ 22' \ 37'' - 35.0dx - 69.9dy.$	9.70007 _n + 18.4 <i>dx</i> + 36.7 <i>dy.</i>

Subtracting a_1 from a_3 and a_6 , we find,

$$\begin{aligned} o_3 &= 97 \ 53 \ 48 - 80.7dx + 12.9dy, \\ o_6 &= 215 \ 59 \ 18 - 87.5dx - 97.0dy, \end{aligned}$$

and by comparing with the observed values,

$$\begin{aligned} 0 &= +321 - 80.7dx + 12.9dy, \\ 0 &= +334 - 87.5dx - 97.0dy, \end{aligned}$$

hence, $dx = +4.^m0$, $dy = -0.^m1$, and $x + dx = 3452.^m0$, $y + dy = +2439.^m9$.

If we now compute the differential equations, using for x and y the above improved values, or 3452 and 2440, the final solution stands as follows:

	1.	2	3.	4.	5.	6.
$y_n - y$	+ 3094.0	+ 46.7	- 2440.0	- 1023.3	- 2041.9	- 1184.3
$x_n - x$	- 1607.0	- 1967.0	- 3452.0	+ 966.2	+ 2711.8	+ 2358.6
$\lg (y_n - y)$	3.4905203 +	1.6693169 +	3.3873898 -	3.0100030 -	3.3100345 -	3.0734117 -
$\lg (x_n - x)$	3.2060159 -	3.2938044 -	3.5380708 -	2.9850670 +	3.4332577 +	3.3726543 +
$\lg \lg a_n$	0.2845044 -	8.3755125 -	9.8493190 +	0.0249360 -	9.8767768 -	9.7008074 -
a_n	117° 26' 49"	178° 38' 24"	215° 15' 15"	313° 21' 22"	323° 01' 17"	333° 20' 16"
$\lg \sin a_n$	9.94814 +	8.37538 +	9.76133 -	9.86159 -	9.77925 -	9.65199 -
$\lg \cos a_n$	9.66363 -	9.99988 -	9.91201 -	9.83666 +	9.90247 +	9.95118 +
$\lg r_n$	3.54239	3.29392	3.62606	3.14841	3.53079	3.42147
$\lg \left(\frac{\sin a_n}{r_n} \right)''$	1.72018 +	0.39589 +	1.44970 -	2.02761 -	1.56289 -	1.54495 -
$\lg \left(\frac{\cos a_n}{r_n} \right)''$	1.43567 -	2.02039 -	1.60038 -	2.00268 +	1.68611 +	1.84414 +
$\sin a_n$	+ 52.50	+ 2.49	- 28.16	- 106.56	- 36.55	- 35.07
$\frac{r_n}{\cos a_n}$	+ 27.27	+ 104.81	+ 39.85	- 100.62	- 48.54	- 69.85
Subtracting a_1		61 11 35	97 48 26	195 54 33	205 34 28	215 53 27
Subtracting $\frac{\sin a_1}{r_1}$		- 50.01	- 80.66	- 159.06	- 89.05	- 87.57
Subtracting $-\frac{\cos a_1}{r_1}$		+ 77.54	+ 12.58	- 127.89	- 75.81	- 97.12

By comparison with the observed angles we obtain the conditional equations:

$$\begin{aligned} 0 &= -35 - 50.01dx + 77.54dy, \\ 0 &= -1 - 80.66dx + 12.58dy, \\ 0 &= -83 - 159.06dx - 127.89dy, \\ 0 &= -36 - 89.05dx - 75.81dy, \\ 0 &= -17 - 87.57dx - 97.11dy. \end{aligned}$$

Normal equations:

$$\begin{aligned} 0 &= +19728 + 49906dx + 30704dy, \\ 0 &= +12268 + 30704dx + 37705dy. \\ dx &= -0.39, dy = -0.01, \text{ and } X = +3451.^m61, Y = +2439.^m99. \end{aligned}$$

If the measured angles are of unequal accuracy, weights are to be introduced before the formation of the normal equations. If we introduce the values of dx and dy in the expressions of du_n , and apply the resulting corrections to the computed a_n , we find, by subtracting a_1 from all the rest, the final corrected angles, which we can compare with the observed angles o_2, o_3, o_4, \dots , when we obtain the residuals, (obs'd—comp'd,)
 "
 "
 "
 "
 "
 "

$$\begin{aligned} v_2 &= +16.0, \\ v_3 &= -30.4, \\ v_4 &= +20.0, \\ v_5 &= +0.9, \\ v_6 &= -17.9, \end{aligned}$$

hence the apparent probable error of any one angle $\varepsilon = \sqrt{\frac{0.455 + 1901}{5-2}} = \pm 17.''0$. The above residuals are in part (the smaller) due to the incidental errors of the observed angles, and in part to inherent errors in the adopted co-ordinates of the known points, which produce for short distances apparently large differences in the angles.

To obtain the uncertainty in the co-ordinates themselves, we form the two sets of weight equations and deduce,

$$\varepsilon_x = \pm 0.^m11, \text{ and } \varepsilon_y = \pm 0.^m12.$$

If all the points fall either in the circumference of a circle or in a straight line, the problem becomes indeterminate; but even an approach to this condition will rarely occur, and is less likely to happen the greater the number of given points above three.

A convenient direct solution of the three-point problem is here presented under a very concise form:

We number the given points in the order of their azimuths, as seen from the fourth point P, which is to be determined, and distinguish three cases, viz: the middle point, P_2 , is on the same side of the line, joining P_1 and P_3 , as is P; or, secondly, P_2 is on the opposite side; or, thirdly, P is inside the triangle P_1, P_2, P_3 . It is only in the second case that we need look for an approach to, or for the limitation of, the problem.

Let $\begin{matrix} P_1 P P_2 = \alpha \\ P_2 P P_3 = \beta \\ P_1 P_2 P_3 = \gamma, \end{matrix}$ the measured angles;
also, $P_2 P_1 P = x,$

$$P P_3 P_2 = y, \text{ put } \operatorname{tg} \varphi = \frac{P_1 P_2 \sin \beta}{P_2 P_3 \sin \alpha} = \frac{\sin y}{\sin x},$$

then for the first case, $x+y = -\alpha-\beta+\gamma$, for the second and third put $360-\gamma$ for γ , and $\operatorname{tg} \frac{1}{2}(x-y) = \frac{\operatorname{tg} \frac{1}{2}(x+y)}{\operatorname{tg}(\varphi+45^\circ)}$.

$$\text{For verification, } P P_2 = P_1 P_2 \frac{\sin x}{\sin \alpha} = P_2 P_3 \frac{\sin y}{\sin \beta}.$$

APPENDIX No. 14.

REPORT ON THE METHOD OF REDUCTION, AND RESULTS OF THE CONNEXION OF THE EPPING BASE LINE WITH THE PRIMARY TRIANGULATION IN THE EASTERN STATES. BY CHARLES A. SCHOTT, ASSISTANT UNITED STATES COAST SURVEY.

COAST SURVEY OFFICE, June 7, 1864.

(1.) *General remarks on the method of reduction.*

The geodetic connexion of the Epping base with the primary triangulation forms the first step in the computation of the great triangulation connecting the Epping and Fire Island base lines with its branch reaching to the Massachusetts base. The application of the method of least squares, without which the reduction could not be satisfactorily accomplished, necessitates, from the complexity of the numerical operations, that the series of triangles should be divided into parts so as to bring each within a limit of practical solution. The number of subdivisions thus practically demanded must be very few, and they should be specially selected to detract as little as possible from the theoretical rigor required by the method. Thus we are obliged to adjust by the method of least squares the angles measured at each station separately, as their introduction in the general geometric condition of the triangulation would swell the conditional equations to hundreds, and indeed there may be a question whether the adjustment of the measures at each station is not the preferable method, reserving a further adjustment to the geometrical requirements of the triangles. Again, the connexion of the Epping base alone with the primary sides of the triangulation, which forms the subject of this report, is so complete as to require the establishment and solution of thirty-five equations, which number would be increased to such an extent, if we were directly to connect one base with the next, as to become perfectly unwieldy. The connexion of the Epping base with the primary side Humpback—Mount Desert may be regarded as a distinct operation, which receives further interest from the fact that it requires a combination of results from measures of angles (by repeating theodolite) and from measures of directions, (direct observations by the thirty-inch theodolite,) also an improved application of weights, and, in general, it may serve, as a specimen, to illustrate the subsequent reduction of the main triangulation of the survey in this section of the country.

(2.) *Instruments and methods of horizontal measures employed in the triangulation near the Epping base.*

The horizontal angles at the base, and at three stations next following, were measured with a repeating theodolite (Coast Survey, No. 43,) by the party in charge of Assistant C. O. Boutelle; those at the remaining four stations were determined by measures of direction with the thirty-inch theodolite (Coast Survey, No. 1.) by the party in charge of Professor A. D. Bache, Superintendent. The first-named instrument is a ten-inch Gambey, read by means of verniers; the second is provided and read with microscopes. The reduction of the angles from observed directions has been sufficiently explained in Coast Survey Report of 1854, pp. 71* to 76*, and for the case when angles were measured by repetition or combination in the same Report, pp. 76* to 79*. The determination of the probable error and weight of each result, however, requires further exposition. It should also be stated that Peirce's criterion has been applied to the reduction of the observations.

(3.) *Determination of probable error and weight to each direction observed with the thirty-inch theodolite.*

The method of obtaining the average probable error and weight of directions measured with the thirty-inch theodolite at any one station has been explained and illustrated in Coast Survey Report of 1854, pp. 86* to 90*, and the small modification required to render the method applicable to *each* direction will appear sufficiently plain from the following example for Station Howard.

To carry out the determination of probable errors in all the theoretical strictness is far too laborious for actual use, and in fact is not required, as a close approximation fully suffices.

We form first the abstract of remaining differences, referred to the initial direction of each series; this abstract is obtained from the abstract of diminished measures by applying the corrections A, B, C, D, etc., with their signs changed to the respective quantities in the abstract of diminished measures; for another initial direction than the first, the proper differences (corrections with reversed sign) are to be applied. Frequently the corrections to the assumed angles are small, less than 0."1; in such cases no correction was required. In forming the abstract all directions are included, whether belonging to the primary series or not; the hundredths of seconds have been dropped. The last column contains the average difference in each series.

STATION HOWARD.

Abstract of remaining differences.

Pigeon.	Mt. Desert.	Burke.	East Base.	Humpback.	Mitten.	Cooper.	Azimuth mark.	Tresecott Rock.	Grand Menan.	Seal Island Light.	Mean.
"	"	"	"	"	"	"	"	"	"	"	"
0.0	0.1	1.7	1.0	3.1	1.8	1.8	1.6	2.4	7.5	0.1	1.9
0.0	1.7	59.7	1.4	2.4	3.7	1.9	1.8	3.3	3.7	2.7	2.0
0.0	4.8	1.1	57.6	1.8	4.5	3.9	0.8	1.3	2.0	59.3	1.5
0.0	1.9	58.7	0.7	59.4	2.4	2.4	1.2	0.2	0.7	59.9	0.7
0.0	57.9	1.8	0.9	57.6	57.8	55.8	55.9	58.0	55.9	59.3	58.3
0.0	0.1	0.0	58.5	55.2	55.0	54.1	54.5	57.5	56.7	56.4	57.1
0.0	53.7	0.4	3.5	56.5	58.9	58.9	59.0	0.2	59.8	1.2	59.3
0.0	2.1	0.3	59.0	58.6	0.5	59.4	58.9	3.1	1.8	0.0	0.3
0.0	58.6	2.5	3.5	0.9	1.0	0.8	1.3	1.4	58.9	58.1	0.6
0.0	59.8	59.9	0.4	2.8	59.5	1.2	59.7	1.3	57.2	58.7	0.0
0.0	59.5	59.4	0.6	4.0	0.1	59.7	1.6	1.3	3.0	1.1	0.9
0.0	5.0	1.7	3.0	4.2	1.8	4.0	3.7	2.1	1.8	59.8	2.5
0.0	0.7	59.4	58.8	1.0	1.9	59.6	58.7	57.9	59.2	2.2	59.9
0.0	3.3	4.6	1.0	55.8	56.9	59.2	1.9	59.3	58.9	2.2	0.3
0.0	58.1	4.1	4.8	53.5	55.5	56.9	57.2	54.3	55.9	58.0	58.0
0.0	59.8	0.2	3.3	1.8	1.0	57.3	58.3	59.5	56.6	59.9	59.8
0.0	2.2	2.3	1.1	4.7	2.3	2.3	3.7	4.3	2.6	1.9	2.5
0.0	0.3	0.6	0.5	3.1	2.4	3.6	1.5	1.0	0.0	59.2	1.1
0.0	2.4	59.4	0.7	2.0	2.8	2.7	3.7	4.0	2.2	3.1	2.1
0.0	57.4	58.6	59.8	0.6	0.4	1.7	2.4	0.9	0.4	0.4	0.2
0.0	0.5	56.5	59.3	2.0	59.6	0.5	3.8	59.3	59.8	1.1	0.2
0.0	0.1	57.6	59.9	59.5	59.7	0.5	59.6	59.7	59.8	59.5	59.6
0.0	0.0	59.2	59.4	3.6	2.9	0.5	1.9	0.6	2.4	-----	1.0
0.0	0.2	2.6	59.4	2.7	0.4	0.6	0.4	1.3	59.9	-----	0.7
0.0	1.0	0.4	58.1	0.2	2.1	1.2	0.9	59.5	0.3	-----	0.4
0.0	59.1	58.9	57.0	55.9	54.0	58.2	56.2	54.9	57.6	-----	57.2
0.0	59.0	59.4	56.2	55.6	56.9	57.0	56.8	0.5	57.0	-----	57.8
0.0	59.2	58.9	2.7	0.3	3.8	0.7	2.4	1.3	0.4	-----	1.0
0.0	58.9	0.7	58.5	59.7	1.8	59.6	0.6	1.7	1.5	-----	0.3
0.0	3.3	0.4	57.6	4.0	2.6	3.7	2.2	0.0	3.7	-----	1.7
0.0	58.5	58.0	56.8	58.8	1.3	58.6	59.5	55.7	0.0	-----	58.7
0.0	59.9	59.7	1.7	1.9	1.1	1.2	1.1	58.8	0.3	-----	0.6
0.0	59.3	58.9	59.4	3.2	59.8	59.3	0.1	4.0	-----	0.8	1.1
0.0	0.9	57.5	58.2	0.2	59.4	0.3	59.3	58.3	-----	58.9	59.3
0.0	58.5	-----	57.0	57.0	58.7	58.6	58.1	0.0	57.3	58.3	58.3
0.0	58.5	58.3	58.8	59.3	1.2	59.7	58.9	-----	58.2	-----	59.2
0.0	59.3	0.0	59.5	1.5	0.9	58.9	59.5	-----	57.8	-----	59.7
0.0	59.8	56.1	58.9	0.6	2.4	0.8	0.9	-----	1.4	-----	0.1
0.0	-----	56.7	1.3	58.9	55.2	58.0	57.5	54.2	-----	59.9	58.0
0.0	-----	2.7	0.1	57.0	0.2	59.2	59.9	-----	59.5	-----	59.8
0.0	57.9	0.9	57.8	2.5	1.3	1.4	58.4	-----	-----	-----	0.0
0.0	-----	0.5	59.8	0.2	-----	59.2	57.9	-----	1.7	-----	59.9
0.0	-----	59.3	56.1	58.3	-----	57.9	59.3	-----	0.1	-----	58.7
0.0	-----	54.7	58.3	56.9	-----	58.3	58.3	-----	56.9	-----	57.7
0.0	-----	-----	0.1	58.8	57.9	58.4	58.7	-----	58.4	-----	58.9
0.0	58.7	1.5	59.6	53.6	54.2	57.1	-----	-----	-----	-----	57.8
0.0	0.7	3.1	2.8	4.1	-----	3.0	3.4	-----	-----	-----	2.5
0.0	-----	-----	1.9	0.3	-----	1.2	0.2	-----	58.4	-----	0.3
0.0	-----	-----	56.6	58.5	-----	0.5	59.5	-----	58.1	-----	58.9
0.0	-----	-----	59.1	1.9	-----	1.2	0.0	-----	1.0	-----	0.5
-----	0.0	2.8	59.0	55.8	54.6	56.4	-----	-----	-----	-----	58.1
-----	0.0	58.6	1.3	56.4	57.2	56.7	-----	-----	-----	-----	58.4
-----	-----	0.0	56.3	56.2	56.2	57.6	57.6	-----	59.1	-----	57.8
-----	0.0	57.9	0.2	57.5	-----	56.6	-----	-----	-----	-----	58.4
-----	0.0	0.1	1.5	59.3	-----	59.9	-----	-----	-----	-----	0.2
-----	0.0	1.2	1.4	1.6	-----	3.0	-----	-----	-----	-----	1.4
-----	-----	-----	-----	-----	-----	0.0	58.8	-----	59.7	-----	59.5
-----	-----	-----	-----	-----	-----	-----	0.0	1.1	-----	59.1	0.1

The abstract of remaining errors is formed by comparing each difference of the preceding abstract with the mean of its series; it contains, therefore, for each measure the difference from the mean; let this difference be Δ , we then form Δ^2 and $\Sigma \Delta^2$ for each direction. If s equal the number of observations of any one direction, the formula $\varepsilon_1^2 = \frac{0.455 \Sigma \Delta^2}{s(s-1)}$ gives an approximation to the square of the probable error of a direction; to give, however, proper weight to the results, since the Δ 's of the more full series are more correct than of series with less directions, it is preferable to substitute for $s-1$ the diagonal coefficient of the weight equations, (omitting the remaining combinations;) this gives for the probable error of the first direction,

$$\varepsilon_1 = \sqrt{\frac{0.455 \Sigma \Delta^2}{s[xx]}};$$

for the second direction, $\varepsilon_1 = \sqrt{\frac{0.455 \Sigma \Delta^2}{s[aa]}};$

for the third direction, $\varepsilon_1 = \sqrt{\frac{0.455 \Sigma \Delta^2}{s[bb]}}$, &c.;

we also have, weight, $w = \frac{1}{\varepsilon_1^2}.$

The labor of squaring is not great in the present case, otherwise the formula, Coast Survey Report of 1856, p. 307, might be employed.

Abstract of remaining errors.

Pigeon.		Mt. Desert.		Burke.		East Base.		Humpback.		Mitten.		Cooper.		Az. mark.		Treseott.		Gr. Men.		Seal I. Lt.	
Δ	Δ^2	Δ	Δ^2	Δ	Δ^2	Δ	Δ^2	Δ	Δ^2	Δ	Δ^2	Δ	Δ^2	Δ	Δ^2	Δ	Δ^2	Δ	Δ^2	Δ	Δ^2
1.9	3.6	1.8	3.2	0.2	0.0	0.9	0.8	1.2	1.4	0.1	0.0	0.1	0.0	0.3	0.1	0.5	0.2	5.6	31.4	1.8	3.2
2.0	4.0	0.3	0.1	2.3	5.3	0.6	0.4	0.4	0.2	1.7	2.9	0.1	0.0	0.2	0.0	1.3	1.7	2.9	0.7	0.5	
1.5	2.2	3.3	10.9	0.4	0.2	3.9	15.2	0.3	0.1	3.0	9.0	2.4	5.8	0.7	0.5	0.2	0.0	0.5	0.2	2.2	4.8
0.7	0.5	1.2	1.4	2.0	4.0	0.0	0.0	1.3	1.7	1.7	2.9	1.7	2.9	0.5	0.2	0.5	0.2	0.0	0.0	0.8	0.6
1.7	2.9	0.4	0.2	3.5	12.2	2.6	6.8	0.7	0.5	0.5	0.2	2.5	6.2	2.4	5.8	0.3	0.1	2.4	5.8	1.0	1.0
2.9	8.4	3.0	9.0	2.9	8.4	1.4	2.0	1.9	3.6	2.1	4.4	3.0	9.0	2.6	6.8	0.4	0.2	0.4	0.2	0.7	0.5
0.7	0.5	5.6	31.4	1.1	1.2	4.2	17.6	2.8	7.8	0.4	0.2	0.4	0.2	0.3	0.1	0.9	0.8	0.5	0.2	1.9	3.6
0.3	0.1	1.8	3.2	0.0	0.0	1.3	1.7	1.7	2.9	0.2	0.0	0.9	0.8	1.4	2.0	2.8	7.8	1.5	2.2	0.3	0.1
0.6	0.4	2.0	4.0	1.9	3.6	2.9	8.4	0.3	0.1	0.4	0.2	0.2	0.0	0.7	0.5	0.8	0.6	1.7	2.9	2.5	6.2
0.0	0.0	0.2	0.0	0.1	0.0	0.4	0.2	2.8	7.8	0.5	0.2	1.2	1.4	0.3	0.1	1.3	1.7	2.8	7.8	1.3	1.7
0.9	0.8	1.4	2.0	1.5	2.2	0.3	0.1	3.1	9.6	0.8	0.6	1.2	1.4	0.7	0.5	0.4	0.2	2.1	4.4	0.2	0.0
2.5	6.2	2.5	6.2	0.8	0.6	0.5	0.2	1.7	2.9	0.7	0.5	1.5	2.2	1.2	1.4	0.4	0.2	0.7	0.5	2.7	7.3
0.1	0.0	0.8	0.6	0.5	0.2	1.1	1.2	1.1	1.2	2.0	4.0	0.3	0.1	1.2	1.4	2.0	4.0	0.7	0.5	2.3	5.3
0.3	0.1	3.0	9.0	4.3	18.5	0.7	0.5	4.5	20.2	3.4	11.6	1.1	1.2	1.6	2.6	1.0	1.0	1.4	2.0	1.9	3.6
2.0	4.0	0.1	0.0	6.1	37.2	6.8	46.2	4.5	20.2	2.5	6.2	1.1	1.2	0.8	0.6	3.7	13.7	2.1	4.4	0.0	0.0
0.2	0.0	0.0	0.0	0.4	0.2	3.5	12.2	2.0	4.0	1.2	1.4	2.5	6.2	1.5	2.2	0.3	0.1	3.2	10.2	0.1	0.0
2.5	6.2	0.3	0.1	0.2	0.0	1.4	2.0	2.2	4.8	0.2	0.0	0.2	0.0	1.2	1.4	1.8	3.2	0.1	0.0	0.6	0.4
1.1	1.2	0.8	0.6	0.5	0.2	0.6	0.4	2.0	4.0	1.3	1.7	2.5	6.2	0.4	0.2	0.1	0.0	1.1	1.2	1.9	3.6
2.1	4.4	0.3	0.1	2.7	7.3	1.4	2.0	0.1	0.0	0.7	0.5	0.6	0.4	1.6	2.6	1.9	3.6	0.1	0.0	1.0	1.0
0.2	0.0	2.8	7.8	1.6	2.6	0.4	0.2	0.4	0.2	0.2	0.0	1.5	2.2	2.2	4.8	0.7	0.5	0.2	0.0	0.2	0.0
0.2	0.0	0.3	0.1	3.7	13.7	0.9	0.8	1.8	3.2	0.6	0.4	0.3	0.1	3.6	13.0	0.9	0.8	0.4	0.2	0.9	0.8
0.4	0.2	0.5	0.2	2.0	4.0	0.3	0.1	0.1	0.0	0.1	0.0	0.9	0.8	0.0	0.0	0.1	0.0	0.2	0.0	0.1	0.0
1.0	1.0	1.0	1.0	1.8	3.2	1.6	2.6	2.6	6.8	1.9	3.6	0.5	0.2	0.9	0.8	0.4	0.2	1.4	2.0	.....	.....
0.7	0.5	0.5	0.2	1.9	3.6	1.3	1.7	2.0	4.0	0.3	0.1	0.1	0.0	0.3	0.1	0.6	0.4	0.8	0.6	.....	.....
0.4	0.2	0.6	0.4	0.0	0.0	2.3	5.3	0.2	0.0	1.7	2.9	0.8	0.6	0.5	0.2	0.9	0.8	0.1	0.0	.....	.....
2.8	7.8	1.9	3.6	1.7	2.9	0.2	0.0	1.3	1.7	3.2	10.2	1.0	1.0	0.4	0.2	2.3	5.3	0.4	0.2	.....	.....
2.2	4.8	1.2	1.4	1.6	2.6	1.6	2.6	2.2	4.8	0.9	0.8	0.8	0.6	1.0	1.0	2.7	7.3	0.8	0.6	.....	.....
1.0	1.0	1.8	3.2	2.1	4.4	1.7	2.9	0.7	0.5	2.8	7.8	0.3	0.1	1.4	2.0	0.3	0.1	0.6	0.4	.....	.....
0.3	0.1	1.4	2.0	0.4	0.2	1.8	3.2	0.6	0.4	1.5	2.2	0.7	0.5	0.3	0.1	1.4	2.0	1.2	1.4	.....	.....
1.7	2.9	1.6	2.6	1.3	1.7	4.1	16.8	2.3	5.3	0.9	0.8	2.0	4.0	0.5	0.2	1.7	2.9	2.0	4.0	.....	.....
1.3	1.7	0.2	0.0	0.7	0.5	1.9	3.6	0.1	0.0	2.6	6.8	0.1	0.0	6.8	0.6	3.0	9.0	1.3	1.7	.....	.....
0.6	0.4	0.7	0.5	0.9	0.8	1.1	1.2	1.3	1.7	0.5	0.2	0.6	0.4	0.5	0.2	1.8	3.2	0.3	0.1	.....	.....
1.1	1.2	1.8	3.2	2.2	4.8	1.7	2.9	2.1	4.4	1.3	1.7	1.8	3.2	1.0	1.0	2.9	8.4	.....	.....	5.7	32.5
0.7	0.5	1.6	2.6	1.8	3.2	1.1	1.2	0.9	0.8	0.1	0.0	1.0	1.0	0.0	0.0	1.0	1.0	.....	.....	0.4	0.2
1.7	2.9	0.2	0.0	.....	.....	1.3	1.7	1.3	1.7	0.4	0.2	0.3	0.1	0.2	0.0	1.7	2.9	1.0	1.0	0.0	0.0
0.8	0.6	0.7	0.5	0.9	0.8	0.4	0.2	0.1	0.0	2.0	4.0	0.5	0.2	0.3	0.1	.....	.....	1.0	1.0	.....	.....

Abstract of remaining errors—Continued.

Pigeon.		Mt. Desert.		Burke.		East Base.		Humpback.		Mitten.		Cooper.		Az. mark.		Trescott.		Gr. Men.		Seal I. Lt.	
Δ	Δ^2	Δ	Δ^2	Δ	Δ^2	Δ	Δ^2	Δ	Δ^2	Δ	Δ^2	Δ	Δ^2	Δ	Δ^2	Δ	Δ^2	Δ	Δ^2	Δ	Δ^2
0.3	0.1	0.4	0.2	0.3	0.1	0.2	0.0	1.8	3.2	1.2	1.4	0.8	0.6	0.2	0.0	.....	.....	1.9	3.6	.....	.....
0.1	0.0	0.3	0.1	4.0	16.0	1.2	1.4	0.5	0.2	2.3	5.3	0.7	0.5	0.8	0.6	.....	.....	1.3	1.7	.....	.....
2.0	4.0	.....	.....	1.3	1.7	3.3	10.9	0.9	0.8	2.8	7.8	0.0	0.0	0.5	0.2	3.8	14.4	.....	.....	1.9	3.6
0.2	0.0	.....	.....	2.9	8.4	0.3	0.1	2.8	7.8	0.2	0.0	0.6	0.4	0.1	0.0	.....	.....	0.3	0.1	.....	.....
0.0	0.0	2.1	4.4	0.9	0.8	2.2	4.8	2.5	6.2	1.3	1.7	1.4	2.0	1.6	2.6	.....	.....	.....	.....	.....	.....
0.1	0.0	.....	.....	0.6	0.4	0.1	0.0	0.3	0.1	.....	.....	0.7	0.5	2.9	4.0	.....	.....	1.8	3.2	.....	.....
1.3	1.7	.....	.....	0.6	0.4	2.6	6.8	0.4	0.2	.....	.....	0.8	0.6	0.6	0.4	.....	.....	1.4	2.0	.....	.....
2.3	5.3	.....	.....	3.0	9.0	0.6	0.4	0.8	0.6	.....	.....	0.6	0.4	0.6	0.4	.....	.....	0.8	0.6	.....	.....
1.1	1.2	.....	.....	.....	.....	1.2	1.4	0.1	0.0	1.0	1.0	0.5	0.2	0.2	0.0	.....	.....	0.5	0.2	.....	.....
2.2	4.8	0.9	0.8	3.7	13.7	1.8	3.2	4.2	17.6	3.6	13.0	0.7	0.5	.....	.....	.....	.....	.....	.....	.....	.....
2.5	6.2	1.8	3.2	0.6	0.4	0.3	0.1	1.6	2.6	.....	.....	0.5	0.2	0.9	0.8	.....	.....	.....	.....	.....	.....
0.3	0.1	.....	.....	.....	.....	1.6	2.6	0.0	0.0	.....	.....	0.9	0.8	0.1	0.0	.....	.....	1.9	3.6	.....	.....
1.1	1.2	.....	.....	.....	.....	2.3	5.3	0.4	0.2	.....	.....	1.6	2.6	0.6	0.4	.....	.....	0.8	0.6	.....	.....
0.5	0.2	.....	.....	.....	.....	1.4	2.0	1.4	2.0	.....	.....	0.7	0.5	0.5	0.2	.....	.....	0.5	0.2	.....	.....
		1.9	3.6	4.7	22.1	0.9	0.8	2.3	5.3	3.5	12.2	1.7	2.9	.....	.....	.....	.....	.....	.....	.....	.....
		1.6	2.6	0.2	0.0	2.9	8.4	2.0	4.0	0.8	0.6	1.7	2.9	.....	.....	.....	.....	.....	.....	.....	.....
		.....	.....	.....	.....	2.2	4.8	1.5	2.2	1.6	2.6	0.2	0.0	0.2	0.0	.....	.....	1.3	1.7	.....	.....
		1.6	2.6	0.5	0.2	1.8	3.2	6.9	0.8	.....	.....	1.8	3.2	.....	.....	.....	.....	.....	.....	.....	.....
		0.2	0.0	0.1	0.0	1.3	1.7	0.9	0.8	.....	.....	0.3	0.1	.....	.....	.....	.....	.....	.....	.....	.....
		1.4	2.0	0.2	0.0	0.0	0.0	0.2	0.0	.....	.....	1.6	2.6	.....	.....	.....	.....	.....	.....	.....	.....
		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.5	0.2	0.7	0.5	.....	.....	0.2	0.0	.....	.....
		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.1	0.0	1.0	1.0	.....	.....	1.0	1.0

	Pigeon.	Mt. Desert.	Burke.	East Base.	Humpback.	Mitten.	Cooper.	Az. mark.	Trescott.	Gr. Men.	S. I. Lt.
Directions.	Sum of Δ^2										
(11)	45.7	90.1	121.6	119.0	96.4	46.9	48.3	46.8	40.6	77.0	44.2
(10)	25.0	20.7	27.9	45.7	32.1	37.3	11.7	6.4	43.5	12.0	32.7
(9)	4.7	0.8	18.6	12.5	4.2	18.5	1.3	0.9	14.4	6.3	3.6
(8)	0.0	4.4	9.2	4.9	14.0	1.7	2.4	2.6	.....	0.1	.....
(7)	19.2	4.0	23.9	11.9	21.1	14.0	2.4	5.6	.....	6.0	.....
(6)	1.5	6.2	22.1	23.9	13.7	15.4	9.7	0.6	.....	6.1	.....
(5)	.....	4.6	0.2	4.9	1.6	.....	5.9	.....	.....	.....	.....
(3)	.....	.....	.....	.....	.....	.....	0.2	0.5	1.0	0.0	1.0
$\Sigma \Delta^2$	96.1	130.8	223.5	222.8	183.1	133.8	81.9	63.4	89.5	107.5	81.5
Diag. coef.	44.6	41.0	44.5	49.5	49.5	41.2	50.2	46.0	33.3	40.9	24.3

	Pigeon.	Mt. Desert.	Burke.	East Base.	Humpback.	Mitten.	Cooper.	Azimuth mark.	Trescott Rock.	Grand Menan.	Seal I'd Light.
s	50	46	50	56	56	46	57	52	37	46	27
$\lg \Sigma \Delta^2$	1.983	2.117	2.349	2.348	2.263	2.126	1.913	1.802	1.998	2.031	1.911
$\lg 0.455 \Sigma \Delta^2$	1.640	1.774	2.007	2.005	1.920	1.784	1.571	1.459	1.655	1.689	1.568
$s[\]$	2230	1886	2225	2772	2772	1895	2861	2392	1232	1881	656
$\lg s[\]$	3.348	3.275	3.347	3.443	3.443	3.278	3.457	3.379	3.091	3.274	2.817
$\lg w = \frac{1}{e_1^2}$	1.708	1.501	1.340	1.438	1.523	1.494	1.836	1.919	1.435	1.585	1.248
w	51.1	31.8	21.9	27.4	33.3	31.2	76.9	83.1	27.3	38.5	17.7
$\lg e_1^2$	8.291	8.498	8.659	8.562	8.477	8.506	8.114	8.080	8.564	8.414	8.751
e_1^2	0.020	0.032	0.046	0.037	0.030	0.032	0.013	0.012	0.037	0.026	0.056
$e_1 = \pm$	0."140	0."177	0."213	0."191	0."173	0."179	0."114	0."110	0."191	0."161	0."238

The average value of ϵ_1 for this station, omitting the secondary directions, Mitten, Trescott Rock, and Seal Island Light, is $\pm 0.''160$.

The probable error ϵ_1 and weight w to each direction, observed with the thirty-inch theodolite, has been computed as shown above; the results are given with the resulting directions at each station.

(4.) *Determination of probable error and weight to each angle and direction from observations with a repeating circle.*

We find by the usual process of comparison of each observed measure of an angle, (in our case of six repetitions, half of which measured with telescope direct, and half with telescope reversed,) with its resulting value, the square of the probable error of any such single measure. This was done for each angle in the abstract of results. The quantity divided by two gives the square of the probable error of any such single direction, or ϵ_1^2 . Thus at East Base we have the following observed angles of six repetitions, each between stations Burke and Tunk:

			Δ				Δ
$^{\circ}$	$'$	$''$	$''$	$^{\circ}$	$'$	$''$	$''$
25	46	40.8	2.6	25	46	44.5	1.1
		41.2	2.2			43.1	0.3
		41.7	1.7			47.2	3.8
		41.5	1.9			44.5	1.1
		40.5	2.9			43.6	0.2
		43.4	0.0			45.0	1.6
		40.3	3.1			45.9	2.5
		45.9	2.5			44.8	1.4
		44.4	1.0			42.5	0.9
		42.4	1.0			44.0	0.6

Average angle $25^{\circ} 46' 43.''36$.

$$\epsilon_0 = 0.845 \frac{\sum J}{\sqrt{n(n-1)}} = \pm 1.''41, \text{ and } \epsilon_1^2 = 0.994.$$

As each direction occurs in several combinations of angles, we can find several values of ϵ_1^2 ; the average value has been taken to represent this quantity. Twenty sets of observations having been made for each angle, we divide the above number by 20, and obtain the square of the probable observing error of a resulting direction, or ϵ^2 .

We next write down the number of times, m , each direction enters in combination with measured angles, (the twenty measures of each angle being now taken as the unit,) and form $\frac{\epsilon^2}{m}$ for each direction.

Thus for station East Base we have:

	Mt. Desert.	Burke.	Tunk.	West Base.	Humpback.	Howard.	Pigeon.
Values of ϵ_1^2 from 14 angles.	0.744	0.994	0.994	0.320	1.095	1.940	1.080
	1.095	1.748	1.080	0.708	1.446	0.871	0.744
	1.940	0.650	1.446	0.594	0.650	0.387	1.748
	0.884	0.594	0.884		0.871		0.387
					0.708		0.320
ϵ_1^2	1.166	0.997	1.101	0.541	0.954	1.066	0.856
ϵ^2	0.0583	0.0499	0.0550	0.0270	0.0477	0.0533	0.0428
m	4	4	4	3	5	3	5
$\frac{\epsilon^2}{m}$	0.0146	0.0125	0.0138	0.0090	0.0095	0.0178	0.0086

We have next to find the combination error resulting from the adjustment of the angles at each station. This error must be taken the same for each direction, and is found by subtracting the observing error from the sum of the combination and observing errors; thus we compare the adjusted angles with the observed angles, taking care at the same time to take out any constant quantity by which repeating angles are liable

to differ constantly by the same small amount; this will give the square of the observing and combination errors, or ε_{0+c}^2 (for any result of twenty measures;) subtracting ε^2 we have the combination error for each direction, $\varepsilon_c^2 = \varepsilon_{0+c}^2 - \varepsilon^2$.

Example of the computation of ε_c^2 for station East Base:

We have here fourteen conditional and six normal equations. Let Δ equal the residual between the adjusted and observed angles, or $A - O$, the sum of the positive values of Δ is 4.90, and of the negative values, 2.11; hence, $\frac{4.90-2.11}{14} = +0.''20$, the quantity by which on the average the angles around East Base were measured too small. This we subtract from each Δ before squaring, and finally deduce $\varepsilon_{0+c}^2 = \frac{0.455 \Sigma (\Delta - .''20)^2}{2(14-6)}$.

$\Delta =$	"	"	"	"
— .30	$\Delta - .20 =$	.50	$(\Delta - .20)^2 =$	.25
+ .42		.22		.05
+ .60		.40		.16
+ .71		.51		.26
— .20		.40		.16
— .22		.42		.18
— .32		.52		.27
— .48		.68		.46
+ .41		.21		.04
+ .95		.75		.56
+ 1.16		.96		.92
+ .62		.42		.18
+ .03		.17		.03
— .59		.79		.62
			$\Sigma =$	4.14

$$\varepsilon_{0+c}^2 = \frac{0.455 \times 4.14}{16} = 0.1178$$

Extracting the root we find ε_{0+c} or the probable combination and observing error for each direction, on the average, as follows:

East Base	± 0.34
West Base	0.28
Burke	0.38
Tunk	0.54
Pigeon	0.34

ε_c^2 being known, we form, lastly, $\frac{\varepsilon^2}{m} + \varepsilon_c^2 = \varepsilon_1^2$, or the square of the final combination and observing error for any resulting direction, a quantity which we use at once to deduce the relative weights to each direction, and which compares directly with the similar quantity derived from the more direct observations with the thirty-inch theodolite.

Station East Base.

	Mt. Desert.	Burke.	Tunk.	W. Base.	Humpback.	Howard.	Pigeon.
ε_{0+c}^2	0.1178	0.1178	0.1178	0.1178	0.1178	0.1178	0.1178
ε^2	0.0583	0.0499	0.0550	0.0270	0.0477	0.0533	0.0428
$\varepsilon_{0+c}^2 - \varepsilon^2 = \varepsilon_c^2$	0.0595	0.0679	0.0628	0.0908	0.0701	0.0645	0.0750
$\varepsilon_c^2 + \frac{\varepsilon^2}{m} = \varepsilon_1^2$	0.0741	0.0804	0.0766	0.0998	0.0796	0.0823	0.0836
$\varepsilon_1 = \pm$	0.''27	0.''28	0.''27	0.''31	0.''28	0.''28	0.''29

(5.) Resulting horizontal angles from the observations at each station, with their probable errors.

The figure, the angles of which have to be adjusted, is a nonagon; (see, for instance, Coast Survey Report for 1862, sketch A, Section I.) The angles at the first five stations, viz: East Base, West Base, Burke, Tunk, and Pigeon, which may be called interior with reference to the large quadrilateral formed by Humpback, Desert, Howard, and Cooper, were measured with a repeating circle; the angles of the four stations last named by the great theodolite giving directions. The consecutive numbers attached to the stations will be used hereafter whenever desirable for the sake of brevity. The value of ε_1 is added to each direction.

(1.) EAST BASE, (EPPING,) 1859.

Repeating Theodolite, No. 43.

		°	'	"	"
7	Desert	0	00	00.00	± 0.27
3	Burke	13	34	42.40	0.28
4	Tunk	39	21	25.46	0.27
2	West Base	65	11	55.30	0.31
6	Humpback	92	52	56.31	0.28
8	Howard	235	22	32.46	0.28
5	Pigeon	329	07	59.80	0.29

(2.) WEST BASE, (EPPING,) 1859.

Repeating Theodolite, No. 43.

		°	'	"	"
1	East Base	0	00	00.00	± 0.19
5	Pigeon	64	55	08.30	0.20
3	Burke	89	03	11.75	0.25
4	Tunk	138	04	57.08	0.23
6	Humpback	217	36	38.06	0.24

(3.) BURKE, 1859.

Repeating Theodolite, No. 43.

		°	'	"	"
6	Humpback	0	00	00.00	± 0.32
2	West Base	35	50	55.63	0.36
9	Cooper	62	44	36.70	0.33
1	East Base	75	10	31.48	0.33
8	Howard	105	30	16.64	0.33
5	Pigeon	176	58	51.30	0.34
7	Desert	236	09	13.84	0.34
4	Tunk	315	37	52.99	0.34

(4.) TUNK, 1859.

Repeating Theodolite, No. 43.

		°	'	"	"
6	Humpback	0	00	00.00	± 0.48
2	West Base	67	44	56.53	0.48
1	East Base	83	49	30.54	0.46
3	Burke	118	30	08.38	0.46
5	Pigeon	144	27	29.16	0.46
7	Desert	201	11	04.45	0.47
	Saunders	275	58	53.08	0.51

(5.) PIGEON, 1859.

Repeating Theodolite, No. 43.

		°	'	"	"
7	Desert	0	00	00.00	± 0.27
	Saunders	45	00	42.99	0.29
4	Tunk	74	49	02.86	0.27
3	Burke	90	12	38.14	0.25
6	Humpback	92	09	19.50	0.26
2	West Base	104	56	40.61	0.26
1	East Base	123	57	37.17	0.27
8	Howard	176	41	31.69	0.25

(6.) HUMPBACK, 1858.

Great Theodolite, No. 1.

		°	'	"	"
9	Cooper	0	00	00.000	± 0.150
—	Azimuth mark	39	37	40.230	0.163
8	Howard	39	45	46.385	0.126
1	East Base	59	43	10.401	0.136
2	West Base	69	38	48.051	0.151
5	Pigeon	84	09	57.099	0.125
3	Burke	85	14	25.280	0.142
4	Tunk	102	22	11.498	0.143
7	Desert	114	33	50.877	0.090
	Ragged	154	28	20.545	0.132
	Saunders	165	12	47.118	0.131
	Harris	180	36	29.988	0.169

(7.) DESERT, 1856.

Great Theodolite, No. 1.

		°	'	"	"
	Isle au Haut	0	00	00.000	± 0.141
	Ragged	33	39	21.332	0.108
	Harris	70	54	51.931	0.121
	Saunders	93	48	58.382	0.103
—	Azimuth mark	122	49	25.136	0.098
6	Humpback	144	20	00.152	0.078
4	Tunk	153	19	24.878	0.107
3	Burke	171	09	49.736	0.148
9	Cooper	175	20	34.430	0.115
1	East Base	176	36	26.634	0.132
8	Howard	199	47	46.624	0.132
5	Pigeon	201	46	49.121	0.110

(8.) HOWAR , 1859.

Great Theodolite, No. 1.

		°	'	"	"
5	Pigeon	0	00	00.000	± 0.140
7	Desert	1	19	25.944	0.177
3	Burke	22	02	34.126	0.213
1	East Base	33	30	40.141	0.191
6	Humpback	51	03	41.505	0.173
9	Cooper	108	01	27.996	0.114
—	Azimuth mark	123	51	19.227	0.110
	Grand Menan	189	28	45.843	0.161

(9.) COOPER, 1859.

Great Theodolite, No. 1.

		°	'	"	"
	Chamcook	0	00	00.000	± 0.117
	Grand Menan	54	40	14.493	0.238
8	Howard	108	56	09.385	0.133
7	Desert	157	47	00.789	0.188
3	Burke	160	11	40.754	0.149
6	Humpback	192	12	43.014	0.259
—	Azimuth mark	294	13	08.804	0.127

(6.) *Effect upon the horizontal angles of a difference of level between the stations occupied and observed upon.*

The effect of a difference of level, h , on the direction, a , of a station in latitude φ equals, (see Lieut. Col. James' English Ordnance Survey, p. 231; also Lieut. Col. Everest's Meridian Arc of India, p. clxvii.)

$\frac{e^2 h}{2r \sin 1''} \sin 2a \cos^2 \varphi$, where r represents the earth's equatorial radius, and e the eccentricity.

To examine the greatest effect of the divergence of the plumb-lines at the two stations upon any direction in our figure, we may take $\varphi = 45^\circ$, and $a = 45^\circ$ also.

Elevation of stations above the sea level.

1	East Base	255 feet.....	By level.
2	West Base.....	239 feet.....	By level.
3	Burke.....	425 feet.....	Approximately.
4	Tunk.....	1150 feet.....	Approximately.
5	Pigeon.....	315 feet.....	By level.
6	Humpback.....	1480 feet.....	Approximately.
7	Desert.....	1530 feet.....	Approximately.
8	Howard.....	269 feet.....	By level.
9	Cooper.....	730 feet.....	Approximately.

Accordingly the direction from East Base to Desert requires a correction of $+0.''02$; the direction from East Base to Humpback, a correction of $-0.''02$; and the direction of Howard to Desert, a correction of $+0.''015$. The corrections will, therefore, not exceed $0.''02$, which quantity, when compared with the probable error of observation, appears sufficiently small to be neglected in the subsequent reduction of the angles.

(7.) *Spherical excess of triangles.*

The computation of the spherical excess, essential to the establishment of the angle equations, as well as to the proper assignment of weights, as will be shown hereafter, was made by the usual formula,

$$\epsilon = \frac{ab \sin C}{2r^2 \sin 1''}$$

where a and b represent the triangle sides, including the angle C , and $r^2 = \frac{A^2}{1 + e^2 \cos 2L}$, for an azimuth of 45° .

The factor, $\frac{1 + e^2 \cos 2L}{2A^2 \sin 1''}$, is taken from the table with the argument L , the latitude of the central point of the surface. The second term of the more complete expression,

$$\epsilon = \frac{ab \sin C}{2r^2 \sin 1''} \left[1 + \frac{1}{24r^2} (a^2 + b^2 + c^2) \right],$$

is so small that it can be neglected; in the largest triangle in the quadrilateral, Humpback, Desert, Cooper, and Howard, it amounts to $0.''0001$.

The computed spherical excesses have been checked by adding those of different triangles forming the same surface.

(8.) *Residuals in the sum of the angles of each triangle and their discussion.*

The nonagon around Epping Base includes forty-six triangles; the spherical excess and error, in the closing of each triangle and its square, is contained in the following table. The triangle is denoted by the respective numbers of the three stations, (as stated in art. 5;) the column headed ϵ contains the spherical excess, and the column headed $S - (180 + \epsilon)$ the error of closing; the last column contains the square of this error. The triangles are arranged in the order of the magnitude of their areas:

Triangle.	ϵ .	$S - 180 - \epsilon$.	Square.	Triangle.	ϵ .	$S - 180 - \epsilon$.	Square.
	"	"			"	"	
6. 8. 7	8.799	— 2.274	5.1711	4. 6. 5	0.962	— 0.763	0.5822
9. 8. 7	7.113	— 1.463	2.1404	4. 7. 3	0.892	— 0.814	0.6626
6. 9. 7	7.000	+ 0.380	0.1444	5. 4. 2	0.886	— 1.726	2.9791
5. 8. 6	5.381	— 0.972	0.9448	1. 8. 3	0.812	+ 0.303	0.0918
6. 8. 9	5.314	+ 1.191	1.4185	2. 4. 6	0.804	+ 0.153	0.0234
8. 9. 3	4.678	+ 0.501	0.2510	4. 7. 6	0.772	— 1.117	1.2477
9. 6. 3	4.168	+ 0.072	0.0052	6. 5. 2	0.725	— 0.807	0.6512
1. 7. 6	3.692	— 0.424	0.1798	1. 5. 3	0.592	+ 0.858	0.7362
5. 7. 6	3.605	— 1.358	1.8442	3. 4. 6	0.585	+ 1.023	1.0465
3. 8. 6	3.532	— 0.618	0.3819	3. 9. 7	0.583	+ 1.216	1.4786
1. 8. 7	3.443	— 1.716	2.9447	2. 1. 5	0.533	— 0.173	0.0299
3. 8. 7	3.018	— 0.748	0.5595	2. 3. 6	0.502	— 1.333	1.7769
3. 7. 6	2.248	— 0.907	0.8226	1. 7. 3	0.387	+ 1.271	1.6154
1. 8. 5	2.141	— 0.140	0.0196	1. 4. 3	0.319	— 0.929	0.8630
3. 8. 5	1.921	+ 0.415	0.1722	1. 6. 2	0.317	+ 0.283	0.0801
4. 7. 5	1.871	+ 0.522	0.2725	3. 5. 4	0.305	— 2.555	6.5280
1. 8. 6	1.664	— 0.134	0.0180	2. 5. 3	0.298	+ 1.292	1.6693
1. 7. 4	1.598	— 0.472	0.2228	2. 3. 4	0.283	— 0.463	0.2144
1. 5. 6	1.576	— 0.698	0.4872	1. 2. 3	0.238	+ 0.262	0.0686
1. 5. 7	1.489	— 1.632	2.6634	2. 1. 4	0.203	+ 0.727	0.5285
1. 6. 4	1.323	+ 1.164	1.3549	5. 8. 7	0.187	— 0.056	0.0031
5. 3. 7	1.284	— 1.219	1.4860	5. 3. 6	0.073	+ 0.768	0.5898
4. 5. 1	1.216	— 2.626	6.8959				
1. 3. 6	1.057	— 0.788	0.6209				
							Sum = 54.4878

Mean error in a triangle, $\sqrt{\frac{54.4878}{46}} = \pm 1.088$

Probable error in a triangle, ± 0.733

Probable error in an angle, ± 0.423

Probable error in a direction, ± 0.299

These quantities include the errors of observation as well as that arising from the formation of triangles.

If we divide the above residuals into two groups, one with positive, the other with negative signs, we find the sums for the two groups..... $= +12.402$
in eighteen cases, and..... $= -28.925$

in twenty-eight cases; the difference, 16.523
divided by 46, gives 0."359; hence, the angles contained in the nonagon are measured, upon the average, too small by 0."120, which is no doubt due to the use of the repeating theodolite, as a similar examination for angles by the great theodolite proved that there was no bias for this latter instrument.

If we form three groups, arranging the triangles according to their size, we find—

Number.	Error of triangle.	Sum of squares.
1 to 15	5 positive, 10 negative.	16.98
15 to 30	4 positive, 11 negative.	19.61
30 to 46	9 positive, 7 negative.	17.90

From which table it appears that the error in the sum of the angles in the triangles may be taken as independent of the size of the triangle; for the smaller triangles the excess and defect in the sum of the angles appears more balanced.

(9.) *Final determination of probable errors (and weights) to each direction.*

The combination of the angles to triangles introduces a new kind of error which must be taken into account; its general effect is to equalize the weights. This triangle error may be supposed to be principally due to lateral refraction; minor causes may be recognized in the imperfect centering of the theodolite over the same vertical observed upon from the other two stations, and in want of parallelism in the verticals at two stations of unequal elevation, and perhaps in other circumstances. If we separate the observing error, previously deduced from the error obtained in art. (8), we obtain the triangle error. For this purpose the probable observing errors of the 276 directions, forming the geometrical figure under consideration, were tabulated, and the average amount was found to be,

$$\epsilon_1 = \pm 0.244.$$

From art. (8) we have,
hence,

$$\epsilon_{1+\Delta} = \pm 0.299;$$

$$\epsilon_{\Delta} = \sqrt{0.299^2 - 0.244^2} = \pm 0.173.$$

The observing error, therefore, slightly exceeds the triangle error, and shows that the latter cannot be neglected in the true valuation of the respective weights.

The final value of the probable error of any direction in the nonagon we obtain, therefore, by combining the observing and triangle error, the latter being constant. We then have,

$$\epsilon = \sqrt{\epsilon_1^2 + \epsilon_{\Delta}^2}, \text{ where } \epsilon_{\Delta}^2 = \pm 0.0299,$$

by which formula the probable errors have been computed. The weight is found by $P = \frac{1}{\epsilon^2}$.

(10.) *Relative value of results from the thirty-inch and the ten-inch repeating theodolites.*

The relative value of the results by these two instruments is only collateral to the present operations of the treatment of the triangulation. From the values of ϵ_1 , in art. (5), the probable observing error of a resulting direction is, on the average, with the great theodolite, $= \pm 0.142$, and with the repeating theodolite, $= \pm 0.321$; the relative weights of the measures by the two instruments, as they have been employed near the Epping Base, are, therefor, on the average as 5:1 respectively.

The ratio of the relative weights actually introduced in the conditional equations is, however, less on the average, owing to the equalizing effect of the additional triangle error; the proportion of the greatest to the east weight there equals 7:1.

(11.) *Formation of the conditional equations of the nonagon around the Epping Base.*

For a sketch of this part of the primary triangulation, Sketch A, Section I, Coast Survey Report of 1862, may be consulted; the stations will be known by their numbers, as given in art. (5). As the formation of the conditional equations and subsequent processes of the method of least squares is fully explained in Coast Survey Report for 1854, pp. 79* to 86*, a few remarks will suffice here.

The number of angle equations between p , occupied points, and l , full (observed forward and backward) lines, is $l - p + 1 = 21$, and the number of side equations between p , points, (occupied or not,) and l , lines, (full or half full, i. e., observed in both or in one direction only,) is $l - 2p + 3 = 14$. The figure therefore demands thirty-five conditional equations.

The side equations may be formed with the plane or the spherical angles, as the ratios of the sides remain equally true, but the use of the spherical angles was found more direct and simple, and for this reason was preferred, (see on this point Bessel's Gradmessung in Ostpreussen, 1838, p. 140.) The conditional equations were at first established commencing with the primary quadrilateral and working towards the base, but the second method was found preferable, viz., commencing with the base and proceeding outward. In the solution of the conditional equations special regard was had to the derived normal equations, in which the

diagonal coefficient should be as large as possible, and the side coefficient as small as possible; the worst conditioned triangles (sum of deviations of each angle from 60° a maximum) and quadrilaterals may be selected; in the latter angles of nearly 90° were avoided, and that station was always selected as pole which either fell within the triangle, (central system,) or which presented the most obtuse angles if outside. Ten-place logarithms (Vega's *Thesaurus Logarithmorum Completus*, Lipsiae, 1794,) were used in establishing the side equations, and the logarithmic difference is there given in units of the fifth place of decimals, (and not the seventh, as heretofore practiced,) which was found more convenient; for angles greater than 35° , and less than 145° , the logarithmic difference for $1''$, as given in the *Thesaurus*, may be used as correct to the last place; all logarithmic differences for $1''$, for small angles, or for angles near 180° , have been specially computed as follows: Let x =small correction (say $1''$) to angle a , then $lg \sin (a+x) = lg \sin a + M \sin 1'' x \cotg a$ where

$$lg(M \sin 1'') = 4.3233591 \ 781$$

and for units of the fifth place of decimals,

$$9.3233592$$

Conditional equations.

Angle equations:

- II. $0 = +0.283 + \left(\frac{1}{2}\right) - \left(\frac{2}{5}\right) + \left(\frac{2}{6}\right) - \left(\frac{1}{6}\right) + \left(\frac{6}{7}\right) - \left(\frac{7}{7}\right)$
- III. $0 = -0.698 + \left(\frac{1}{3}\right) - \left(\frac{2}{5}\right) + \left(\frac{5}{6}\right) - \left(\frac{1}{6}\right) + \left(\frac{6}{7}\right) - \left(\frac{5}{7}\right)$
- IV. $0 = -0.807 + \left(\frac{2}{5}\right) - \left(\frac{2}{5}\right) + \left(\frac{5}{6}\right) - \left(\frac{2}{6}\right) + \left(\frac{2}{7}\right) - \left(\frac{5}{7}\right)$
- VI. $0 = +1.292 + \left(\frac{3}{2}\right) - \left(\frac{5}{2}\right) + \left(\frac{2}{5}\right) - \left(\frac{3}{5}\right) + \left(\frac{5}{6}\right) - \left(\frac{2}{6}\right)$
- VII. $0 = +0.768 + \left(\frac{5}{3}\right) - \left(\frac{6}{3}\right) + \left(\frac{3}{6}\right) - \left(\frac{5}{6}\right) + \left(\frac{6}{7}\right) - \left(\frac{3}{7}\right)$
- IX. $0 = -0.788 + \left(\frac{1}{3}\right) - \left(\frac{2}{3}\right) + \left(\frac{3}{6}\right) - \left(\frac{1}{6}\right) + \left(\frac{6}{7}\right) - \left(\frac{3}{7}\right)$
- XI. $0 = -2.555 + \left(\frac{4}{3}\right) - \left(\frac{5}{3}\right) + \left(\frac{3}{5}\right) - \left(\frac{4}{5}\right) + \left(\frac{5}{6}\right) - \left(\frac{3}{6}\right)$
- XII. $0 = -1.726 + \left(\frac{5}{4}\right) - \left(\frac{2}{4}\right) + \left(\frac{4}{5}\right) - \left(\frac{5}{5}\right) + \left(\frac{2}{6}\right) - \left(\frac{4}{6}\right)$
- XIV. $0 = -0.929 + \left(\frac{1}{3}\right) - \left(\frac{4}{3}\right) + \left(\frac{3}{4}\right) - \left(\frac{1}{4}\right) + \left(\frac{4}{5}\right) - \left(\frac{3}{5}\right)$
- XVI. $0 = +0.153 + \left(\frac{4}{6}\right) - \left(\frac{2}{6}\right) + \left(\frac{6}{7}\right) - \left(\frac{4}{7}\right) + \left(\frac{2}{8}\right) - \left(\frac{6}{8}\right)$
- XVIII. $0 = -0.907 + \left(\frac{6}{5}\right) - \left(\frac{7}{5}\right) + \left(\frac{3}{7}\right) - \left(\frac{6}{7}\right) + \left(\frac{7}{8}\right) - \left(\frac{3}{8}\right)$
- XIX. $0 = -1.117 + \left(\frac{7}{6}\right) - \left(\frac{4}{6}\right) + \left(\frac{6}{7}\right) - \left(\frac{7}{7}\right) + \left(\frac{4}{8}\right) - \left(\frac{6}{8}\right)$
- XXI. $0 = +1.271 + \left(\frac{3}{7}\right) - \left(\frac{7}{7}\right) + \left(\frac{7}{8}\right) - \left(\frac{3}{8}\right) + \left(\frac{7}{9}\right) - \left(\frac{7}{9}\right)$
- XXIII. $0 = -1.358 + \left(\frac{8}{5}\right) - \left(\frac{7}{5}\right) + \left(\frac{5}{7}\right) - \left(\frac{8}{7}\right) + \left(\frac{7}{8}\right) - \left(\frac{5}{8}\right)$
- XXV. $0 = +0.303 + \left(\frac{3}{8}\right) - \left(\frac{8}{8}\right) + \left(\frac{8}{9}\right) - \left(\frac{3}{9}\right) + \left(\frac{8}{10}\right) - \left(\frac{8}{10}\right)$
- XXVI. $0 = -0.134 + \left(\frac{1}{6}\right) - \left(\frac{8}{6}\right) + \left(\frac{6}{8}\right) - \left(\frac{1}{8}\right) + \left(\frac{8}{9}\right) - \left(\frac{6}{9}\right)$
- XXVIII. $0 = -1.716 + \left(\frac{7}{8}\right) - \left(\frac{8}{8}\right) + \left(\frac{8}{9}\right) - \left(\frac{7}{9}\right) + \left(\frac{8}{10}\right) - \left(\frac{7}{10}\right)$
- XXX. $0 = -0.056 + \left(\frac{8}{5}\right) - \left(\frac{3}{5}\right) + \left(\frac{5}{7}\right) - \left(\frac{8}{7}\right) + \left(\frac{7}{8}\right) - \left(\frac{5}{8}\right)$
- XXXII. $0 = +1.216 + \left(\frac{7}{3}\right) - \left(\frac{3}{3}\right) + \left(\frac{3}{9}\right) - \left(\frac{7}{9}\right) + \left(\frac{9}{10}\right) - \left(\frac{3}{10}\right)$
- XXXIII. $0 = +0.380 + \left(\frac{7}{6}\right) - \left(\frac{2}{6}\right) + \left(\frac{6}{9}\right) - \left(\frac{7}{9}\right) + \left(\frac{9}{10}\right) - \left(\frac{6}{10}\right)$
- XXXV. $0 = -1.463 + \left(\frac{8}{7}\right) - \left(\frac{9}{7}\right) + \left(\frac{7}{9}\right) - \left(\frac{8}{9}\right) + \left(\frac{9}{10}\right) - \left(\frac{7}{10}\right)$

Side equations:

- I. $0 = +2.17807 + 0.40132(\frac{6}{1}) - 0.37895(\frac{2}{1}) + 0.61094(\frac{1}{5}) - 1.53850(\frac{2}{5}) + 0.81302(\frac{5}{6}) - 2.01607(\frac{2}{6})$
 $+ 2.20305(\frac{1}{6}) - 0.02237(\frac{5}{1}) + 0.92756(\frac{6}{5})$
- V. $0 = -6.12588 + 0.80064(\frac{2}{5}) + 5.39998(\frac{3}{5}) + 10.47161(\frac{2}{6}) - 11.22604(\frac{5}{6}) - 6.20062(\frac{6}{5}) + 0.75443(\frac{2}{6})$
 $- 0.16782(\frac{2}{5}) - 0.30212(\frac{3}{5}) + 0.46994(\frac{5}{2})$
- VIII. $0 = +0.08483 + 0.25700(\frac{1}{3}) - 0.54841(\frac{2}{3}) + 0.29141(\frac{6}{5}) + 0.75443(\frac{2}{6}) - 1.95748(\frac{2}{6}) + 1.20305(\frac{1}{6})$
 $+ 0.40132(\frac{6}{1}) + 0.16676(\frac{1}{3}) - 0.56808(\frac{2}{1})$
- X. $0 = -1.34263 + 0.18284(\frac{4}{2}) - 0.65278(\frac{3}{2}) + 0.46994(\frac{5}{2}) + 0.80064(\frac{2}{5}) - 1.56540(\frac{3}{5}) + 0.76476(\frac{4}{5})$
 $+ 0.43254(\frac{5}{4}) - 0.60454(\frac{3}{4}) + 0.17200(\frac{2}{4})$
- XIII. $0 = -0.68771 + 0.31512(\frac{1}{5}) - 1.07988(\frac{3}{5}) + 0.76476(\frac{4}{5}) + 0.43254(\frac{5}{4}) - 0.73688(\frac{3}{4}) + 0.30434(\frac{1}{4})$
 $+ 0.43596(\frac{1}{1}) - 0.65063(\frac{3}{1}) + 0.21467(\frac{5}{1})$
- XV. $0 = -1.58338 + 0.73062(\frac{1}{4}) - 0.81676(\frac{2}{4}) + 0.08614(\frac{6}{4}) + 0.32768(\frac{4}{6}) - 1.53073(\frac{2}{6}) + 1.20305(\frac{1}{6})$
 $+ 0.40132(\frac{6}{1}) - 0.83606(\frac{2}{1}) + 0.43474(\frac{4}{1})$
- XVII. $0 = +0.22432 + 0.65422(\frac{2}{7}) - 1.98508(\frac{4}{7}) + 1.33086(\frac{6}{7}) + 0.97432(\frac{7}{6}) - 1.65748(\frac{4}{6}) + 0.68316(\frac{3}{6})$
 $+ 0.21525(\frac{6}{3}) - 0.25436(\frac{4}{3}) + 0.03911(\frac{7}{3})$
- XX. $0 = -1.83218 + 2.20947(\frac{1}{7}) - 2.62575(\frac{3}{7}) + 0.41628(\frac{6}{7}) + 0.37484(\frac{7}{6}) - 0.81586(\frac{3}{6}) + 0.44102(\frac{1}{6})$
 $+ 0.03977(\frac{6}{1}) - 0.91152(\frac{3}{1}) + 0.87175(\frac{7}{1})$
- XXII. $0 = -0.44146 + 0.67443(\frac{6}{5}) - 0.73156(\frac{4}{5}) + 0.05713(\frac{7}{5}) + 0.18656(\frac{5}{7}) - 1.51742(\frac{4}{7}) + 1.33086(\frac{6}{7})$
 $+ 0.97432(\frac{7}{6}) - 1.61457(\frac{4}{6}) + 0.64025(\frac{5}{6})$
- XXIV. $0 = +0.92970 + 0.44102(\frac{3}{5}) - 1.02088(\frac{1}{5}) + 0.57986(\frac{6}{5}) + 0.66575(\frac{6}{5}) - 1.70358(\frac{1}{5}) + 1.03783(\frac{3}{5})$
 $+ 0.35990(\frac{6}{5}) - 0.41562(\frac{1}{5}) + 0.05572(\frac{6}{5})$
- XXVII. $0 = -1.36912 + 0.66575(\frac{6}{5}) - 1.00027(\frac{1}{5}) + 0.33452(\frac{7}{5}) + 0.49153(\frac{6}{7}) - 0.82493(\frac{1}{7}) + 0.33340(\frac{6}{7})$
 $+ 0.14829(\frac{7}{6}) - 0.72815(\frac{1}{6}) + 0.57986(\frac{6}{6})$
- XXIX. $0 = +0.51527 + 0.35890(\frac{7}{6}) - 0.57388(\frac{5}{6}) + 0.21498(\frac{6}{6}) + 0.17014(\frac{6}{6}) + 8.94070(\frac{5}{6}) - 9.11084(\frac{7}{6})$
 $+ 5.94358(\frac{5}{7}) - 6.07800(\frac{6}{7}) + 0.13442(\frac{6}{7})$
- XXXI. $0 = -1.75954 + 0.33673(\frac{6}{5}) - 5.33719(\frac{3}{5}) + 5.00046(\frac{7}{5}) + 2.88157(\frac{9}{7}) + 3.29785(\frac{2}{7}) + 0.41628(\frac{6}{7})$
 $+ 0.37484(\frac{7}{6}) - 0.39237(\frac{3}{6}) + 0.01753(\frac{6}{6})$
- XXXIV. $0 = +0.82217 + 4.83153(\frac{3}{5}) - 5.00046(\frac{7}{5}) + 0.16893(\frac{6}{5}) + 0.01479(\frac{6}{5}) - 0.57145(\frac{3}{5}) + 0.55666(\frac{7}{5})$
 $+ 0.38566(\frac{6}{7}) + 2.49591(\frac{2}{7}) - 2.88157(\frac{9}{7})$

In the equations of correlatives four places of decimals have been retained.

correlatives.

V.	VIII.	X.	XIII.	XV.	XVII.	XX.	XXII.	XXIV.	XXVII.	XXIX.	XXXI.	XXXIV.
	-0.5681 +0.1668		-0.6506 +0.4360 +0.2147	-0.8361 +0.4347 +0.4013		-0.9115						
	+0.4013					+0.0398 +0.8718						
- 0.3021		-0.6528 +0.1828 +0.4699										
+ 0.4699 - 0.1678												
	+0.2570 -0.5484				-0.2544			-0.4156				
	+0.2914				+0.2153 +0.0391			+0.0557 +0.3559				
		+0.1720 -0.6045 +0.4325	+0.3043 +0.7369 +0.4325	+0.7306 -0.8168 +0.0861								
+ 0.8006 + 5.4000 - 6.2006		+0.8006 -1.5654 +0.7648	+0.3151 -1.0799 +0.7648				-0.7316 +0.6743 +0.0571					
+ 0.7544 +10.4716 -11.2260	+1.2030 -1.9575 +0.7544			+1.2030 -1.5307 +0.3277	+0.4410 +0.6832 -1.6575 +0.9743	-0.8159 -1.6146 +0.6403 +0.3748	+0.4410 +0.4410 +0.9743	-1.0209 +0.4410 +0.5799	-0.7282 +0.1483 +0.5799	-0.5739 +0.3589 +0.2150	-0.3924 +0.3748 +0.0175	
					+0.6542 -1.9851 +1.3309	+2.2895 -2.6258 +0.4163	-1.5174 +0.1866 +1.3309	-0.8249 +0.3334 +0.4915	-0.8249 +0.3334 +0.4915	+5.9436 +0.1344 -6.0780	-3.2978 +0.1463 +2.8816	+2.4959 +0.3857 -2.8816
								-1.7036 +1.0378 +0.6658	-1.0003 +0.6658 +0.3345	+8.9407 +0.1701 -9.1108		-0.5715 +0.5567 +0.0148
											-5.3372 +0.3367 +5.0005	+4.8315 -5.0005 +0.1689

Normal equations.

	II	III	IV	V	VI	VII	IX	XI	XII	XIV	XVI	XVIII	XIX	XXI	XXIII	XXV	XXVI	XXVIII	XXX
0 =																			
+0.283	+0.490	+0.157	-0.140				+0.157				-0.140						-0.157		
-0.098	+0.157	+0.515	+0.144			-0.144	+0.157				+0.140				-0.144		-0.157		
-0.097	-0.140	+0.144	+0.452		+0.168	-0.144			+0.168										
+1.292			+0.168		+0.660	+0.242		-0.242	+0.168										
+0.768		-0.144	-0.144		+0.242	+0.568	+0.182	-0.242				-0.182			+0.144				
-0.788	+0.157	+0.157			-0.242	+0.182	+0.568	-0.242		+0.247		-0.182		-0.247		-0.247	-0.157		
-2.555			+0.768		+0.168	-0.242		+0.343	+0.851		-0.340								
-1.726							+0.247	-0.357		+0.976				-0.247					
-0.929			+0.140				-0.182		-0.340		+0.790		-0.310						
+0.153	-0.140					-0.182						+0.452	+0.074	-0.196	+0.074				
-0.907							-0.247				-0.310	+0.074	+0.676		+0.074				
-1.117										-0.247				+0.593		+0.247			
+1.271		-0.144	-0.144			+0.144						+0.074	+0.074		+0.365			-0.150	+0.147
-1.358							-0.247			-0.247				+0.247		+0.642	-0.177	+0.177	
+0.303		-0.157					-0.157									-0.177	+0.440	-0.177	
-0.134														-0.150		+0.177	-0.177	-0.110	
-1.716															+0.147		-0.110	+0.401	
-0.056												-0.196		+0.196					
+1.216												+0.074	+0.074		+0.074		+0.110	-0.110	
+0.380																	+0.056		
-1.463		-0.0043	-0.0974		-0.1508	+0.0535	-0.0156		-0.1508		+0.1069				+0.0535				
+2.1791	-0.0740	+0.0913	+0.0823		-0.4901	-0.0753	+0.5236	+0.5076	+0.0456		-0.0546	-0.3236			-0.0913				
6.1259	+0.0546	+0.0156	+0.1037		+0.0861	-0.0007	+0.0013		+0.0177	+0.0177	+0.1037	+0.0007		-0.0177		-0.0177	+0.0156		
+0.0848			+0.0456		+0.1320	+0.1472		+0.0224	+0.0407	-0.1457									
-1.3436					+0.1015	+0.1015	+0.0703	+0.0699	+0.0238	-0.1337			+0.0056	-0.0703					
-0.8877	+0.0103	+0.0081	+0.0811			+0.0657	-0.0156		+0.2091	-0.1375	-0.1335		+0.0118	-0.0284	-0.0109		+0.0156		
-1.8834		-0.0156				+0.0408	+0.0057	-0.0371		+0.0371	-0.0845		-0.0965	-0.0007	-0.0007	-0.0984	+0.0173		
+0.2243	-0.0173	-0.0173				+0.0368	+0.0403	+0.0761	+0.0761	-0.0578	-0.0823		-0.0109	+0.0077	+0.0276			-0.0171	
-0.4415			-0.0366			+0.0147	+0.0070					-0.0147				-0.0841	+0.0774	-0.1141	+0.0018
+0.9297	+0.0500	+0.0500					+0.0357					-0.0064	-0.0064	-0.0396	-0.0064	-0.0670	+0.0446	-0.0246	-0.0028
-1.3691	-0.0357	+0.0357										+0.0068	+0.0068		+0.2848		+0.0003	+0.9731	-0.4705
+0.5133		-0.0254				+0.0264	-0.0196					-0.1536	-0.0007	+0.1715	-0.0007	+0.0434		-0.0160	+0.0160
-1.7595																			
+0.6222												+0.1298		-0.1298					

The solution of the normal equations was effected by application of the method of indirect elimination, (Coast Survey Report of 1855, Appendix No. 40.) and was broken off after securing the perfect adjustment of the hundredths of seconds in the angles, and nearly the last unit in the seventh place of logarithms of length of sides. The computation of the forty-six triangles showed that the remaining difference in the sum of the angles was, upon the average, a little less than 0."003, and in maximo it amounted to 0."007, which was thought to be a sufficiently close adjustment, considering that the measured angles, with the repeating theodolite, are only given to the nearest, 0."01 in the abstract, and are liable to an average probable error of $\pm 0."45$; the angles measured with the great theodolite have an average probable error of $\pm 0."20$, (as found from the probable error of the directions in preceding abstract of angles, art. 5.) The logarithms of the distances show a corresponding degree of differences from the mean, amounting, upon the average, to less than a unit in the seventh place of decimals, and in maximo to two units in that place, the uncertainty in the measure of the base being nearly $\frac{1}{550000}$ of its length; the logarithm of the base is uncertain by eight units in the seventh place of decimals. It might be remarked in this place that—

Of 15 sides we have 4 independent values for each.

Of 8 sides we have 3 independent values for each.

Of 3 sides we have 2 independent values for each.

Of 3 sides we have 1 independent value for each.

Table of correlatives resulting from the solution of the normal equations.

II	= - 3.358	XXXII	= - 7.795
III	+ 8.923	XXXIII	+ 3.280
IV	+ 1.421	XXXV	- 1.168
VI	- 12.538	I	- 21.566
VII	+ 12.900	V	- 0.485
IX	- 1.519	VIII	+ 18.103
XI	+ 3.839	X	- 8.428
XII	- 3.486	XIII	+ 11.827
XIV	+ 4.992	XV	+ 3.918
XVI	- 0.995	XVII	- 10.152
XVIII	+ 8.987	XX	+ 12.972
XIX	- 0.252	XXII	+ 12.028
XXI	+ 13.227	XXIV	- 29.368
XXIII	+ 2.295	XXVII	+ 51.563
XXV	+ 3.565	XXIX	- 0.0271
XXVI	+ 4.168	XXXI	- 24.943
XXVIII	+ 3.903	XXXIV	- 35.537
XXX	+ 1.732		

(13.) *Resulting corrections to the observed directions.*

Substituting the above in the weighted equations of correlatives, we obtain the following corrections to the observed directions:

($\frac{1}{2}$) = - 0.260 ($\frac{1}{2}$) = - 0.218	($\frac{1}{3}$) = + 0.492 ($\frac{1}{3}$) = + 0.348	($\frac{1}{4}$) = - 0.053 ($\frac{1}{4}$) = - 0.058	($\frac{1}{5}$) = - 0.218 ($\frac{1}{5}$) = + 0.117	($\frac{1}{6}$) = + 0.364
($\frac{2}{3}$) = - 0.343 ($\frac{2}{3}$) = - 0.641	($\frac{2}{4}$) = + 0.410 ($\frac{2}{4}$) = - 0.553	($\frac{2}{5}$) = + 1.121 ($\frac{2}{5}$) = - 0.111	($\frac{2}{6}$) = - 0.552 ($\frac{2}{6}$) = - 1.044	($\frac{2}{7}$) = - 0.823
($\frac{3}{4}$) = + 1.244 ($\frac{3}{4}$) = - 0.339	($\frac{3}{5}$) = + 0.209 ($\frac{3}{5}$) = - 0.595	($\frac{3}{6}$) = + 0.120 ($\frac{3}{6}$) = - 0.289	($\frac{3}{7}$) = + 0.069 ($\frac{3}{7}$) = - 0.099	($\frac{3}{8}$) = + 0.417
($\frac{4}{5}$) = - 0.661 ($\frac{4}{5}$) = + 0.729	($\frac{4}{6}$) = - 0.515 ($\frac{4}{6}$) = + 0.436	($\frac{4}{7}$) = - 0.681 ($\frac{4}{7}$) = - 0.105	($\frac{4}{8}$) = + 0.257 ($\frac{4}{8}$) = + 1.136	($\frac{4}{9}$) = - 0.232
($\frac{5}{6}$) = + 0.062 ($\frac{5}{6}$) = + 0.336	($\frac{5}{7}$) = - 0.124 ($\frac{5}{7}$) = + 0.280	($\frac{5}{8}$) = - 0.395 ($\frac{5}{8}$) = - 0.424	($\frac{5}{9}$) = - 0.136 ($\frac{5}{9}$) = - 0.204	
($\frac{6}{7}$) = + 0.202 ($\frac{6}{7}$) = - 0.569	($\frac{6}{8}$) = + 0.063 ($\frac{6}{8}$) = - 0.351	($\frac{6}{9}$) = + 0.590 ($\frac{6}{9}$) = + 0.615	($\frac{6}{10}$) = - 0.073	
($\frac{7}{8}$) = - 0.363 ($\frac{7}{8}$) = - 0.995	($\frac{7}{9}$) = + 0.163 ($\frac{7}{9}$) = + 0.400	($\frac{7}{10}$) = - 0.070		
($\frac{8}{9}$) = + 1.076				

If we form the squares of these corrections, and divide their sum by 58, we find the average square, and by extracting the root we obtain the average correction to a direction, as demanded by the geometrical conditions of the figure,

$$\sqrt{\frac{15.0199}{58}} = \pm 0.509 \text{ for a direction, and}$$

$$\pm 0.720 \text{ for an angle;}$$

values much greater than those resulting from the errors in the measures at any one station, or from their combinations to form triangles, (compare with ϵ_1 and $\epsilon_{1+\Delta}$ of art. 9.) The error, therefore, arising from a want of perfect intersection of the lines of sight at any one station is the greatest; it may be called "intersection error." This consideration shows that we have even now too much diversity in our assigned weights in the equations of correlatives.

(14.) *Complete adjustment of the nonagon and final directions.*

For the subsequent computation of the triangle sides and the introduction and discussion of the astronomical azimuths, it is desirable to have the adjustment of the whole figure perfect, the triangles to 0."001, and the logarithmic distances to the eighth place of decimals; an additional differential or second order adjustment by least squares of the remaining small discrepancies, neglecting weights, was therefore added to the preceding general adjustment. For this purpose the figure was divided into three parts, and each adjusted separately, without reacting on the preceding. The first part comprised the base pentagon, which forms a separate system, the angles of which were measured by repetition; it involved nine conditional equations between the second-order discrepancies, (or six angle and three side equations;) the second part connects the pentagon with the side Humpback-Desert by means of fourteen equations, (eight angle and six side equations;) the third part joins the last points, Howard and Cooper, to the preceding figure by means of twelve equations, (seven angle and five side equations.) As this secondary process involves no new feature, the resulting small additional corrections to each direction, resulting from it, are at once presented in the table below; these should be added to the corrections given in the preceding article:

"		"		"	
(2)	= - 0.003	(6)	= - 0.006	(8)	= - 0.006
(3)	0.000	(7)	+ 0.011	(9)	- 0.013
(4)	+ 0.004	(8)	- 0.005	(10)	- 0.015
(5)	- 0.004	(9)	+ 0.007	(11)	+ 0.016
(6)	- 0.002	(10)	+ 0.010	(12)	+ 0.009
(7)	- 0.001	(11)	+ 0.001	(13)	+ 0.010
(8)	- 0.003	(12)	- 0.006	(14)	- 0.002
(9)	+ 0.002	(13)	+ 0.005	(15)	- 0.005
(10)	0.000	(14)	- 0.006	(16)	- 0.002
(11)	+ 0.002	(15)	- 0.003	(17)	- 0.012
(12)	0.000	(16)	- 0.001	(18)	+ 0.010
(13)	+ 0.001	(17)	+ 0.007	(19)	+ 0.007
(14)	+ 0.003	(18)	+ 0.002	(20)	+ 0.003
(15)	- 0.002	(19)	+ 0.005	(21)	+ 0.007
(16)	+ 0.001	(20)	- 0.007	(22)	- 0.012
(17)	- 0.001	(21)	+ 0.013	(23)	+ 0.010
(18)	- 0.001	(22)	+ 0.010	(24)	- 0.002
(19)	+ 0.004	(23)	- 0.006	(25)	+ 0.006
(20)	0.000	(24)	- 0.010		
(21)	- 0.002	(25)	- 0.007		

The following table contains the adjusted directions at each station:

1. EAST BASE.			2. WEST BASE.			3. BURKE.			4. TUNK.			5. PIGEON.		
	°	' "		°	' "		°	' "		°	' "		°	' "
7	0	00 00.000	1	0	00 00.000	6	0	00 00.000	6	0	00 00.000	7	0	00 00.000
3	13	34 41.844	5	64	55 09.251	2	35	50 56.159	2	67	44 55.694	4	74	49 02.534
4	39	21 26.495	3	89	03 11.328	9	62	44 37.879	1	83	49 30.610	3	90	12 38.617
2	65	11 54.824	4	138	04 56.958	1	75	10 32.089	3	118	30 07.505	6	92	09 19.467
6	92	52 56.153	6	217	36 38.611	8	105	30 15.749	5	144	27 29.314	2	104	56 42.092
8	235	22 31.878				5	176	58 50.903	7	201	11 04.226	1	123	57 37.473
5	329	07 58.922				7	236	09 13.398				8	176	41 32.226
						4	315	37 53.316						

6. HUMPBACK.			7. DESERT.			8. HOWARD.			9. COOPER.		
	°	' "		°	' "		°	' "		°	' "
9	0	00 00.000	6	0	00 00.000	5	0	00 00.000	8	0	00 00.000
Az. m.	39	37 40.403	4	8	59 24.932	7	1	19 25.832	7	48	50 52.045
8	39	45 46.990	3	26	49 49.185	3	22	02 33.158	3	51	15 31.948
1	59	43 10.536	9	31	00 34.346	1	33	30 40.345	6	83	16 33.042
2	69	38 48.135	1	32	16 26.420	6	51	03 42.737	Az. m.	185	16 59.577
5	84	09 56.876	8	55	27 47.228	9	108	01 28.018			
3	85	14 25.195	5	57	26 49.358	Az. m.	123	51 19.290			
4	102	22 11.591	Az. m.	338	29 25.121						
7	114	33 51.656									

Computation of triangle sides—Continued.

No.	Stations.	No.	Observed angles.	Corr.	SECONDS OF—			Logarithms.
					Spherical angles.	Spherical excess.	Plane angles and distances.	
			° ' "	"	"	"	"	
5	Pigeon	5	19 00 56.560	—1.180	55.380	.178	55.362	3.9403143 4
	West Base	2	64 55 08.300	— .951	09.251	.178	09.073	0.4870206 8
	East Base	1	96 03 55.500	+ .402	55.902	.177	55.725	9.9569895 5
6	Pigeon	5	33 44 59.030	— .174	58.856	.197	58.659	9.9975619 0
	Burke	3	101 48 19.820	—1.005	18.815	.197	18.617	4.3843245 7
	East Base	1	44 26 42.600	+ .322	43.932	.198	42.734	4.4248969 2
7	Pigeon	5	49 08 34.310	+ .629	34.939	.405	34.534	4.1384436 4
	Tunk	4	60 37 58.620	+ .684	58.704	.405	58.299	0.2552652 6
	East Base	1	70 13 25.660	+1.913	27.573	.406	27.167	9.9907156 7
8	Pigeon	5	14 44 02.470	+1.006	03.476	.099	03.377	9.8453387 1
	Burke	3	141 07 55.670	— .925	54.745	.100	54.645	4.3843245 6
	West Base	2	24 08 03.450	—1.373	02.077	.099	01.978	4.2388476 1
9	Pigeon	5	30 07 37.750	+1.809	39.559	.295	39.264	4.1373282 4
	Tunk	4	76 42 32.630	+ .990	33.630	.296	33.334	0.2993594 2
	West Base	2	73 09 48.780	—1.073	47.707	.295	47.412	9.9882062 5
10	Pigeon	5	15 23 33.280	+ .803	36.083	.101	35.982	9.9809725 2
	Tunk	4	25 57 20.780	+1.029	21.809	.102	21.707	4.4248969 1
	Burke	3	138 39 01.690	+ .723	02.413	.102	02.311	4.4176601 8
11	Humpback	6	9 55 37.650	— .051	37.589	.105	37.494	4.0216623 3
	East Base	1	27 41 01.010	+ .320	01.330	.106	01.233	0.5560273 3
	West Base	2	142 23 21.940	— .551	21.389	.106	21.283	9.6411579 5
12	Humpback	6	25 31 14.879	— .220	14.659	.352	14.307	9.8199705 2
	East Base	1	79 18 13.910	+ .400	14.310	.352	13.957	4.2388476 1
	Burke	3	75 10 31.480	+ .609	32.089	.353	31.736	4.4176601 8
13	Humpback	6	42 39 01.097	— .042	01.055	.441	00.614	4.1384436 4
	East Base	1	53 31 30.850	—1.192	29.658	.441	29.217	0.3656877 9
	Tunk	4	83 49 30.540	+ .070	30.610	.441	30.169	9.9923879 7
14	Humpback	6	24 26 46.698	— .358	46.340	.525	45.815	9.9952880 0
	East Base	1	123 44 56.510	+ .721	57.231	.525	56.706	4.4964193 9
	Pigeon	5	31 48 17.670	+ .335	18.005	.526	17.479	4.4893294 3

REPORT OF THE SUPERINTENDENT OF

Computation of triangle sides—Continued.

No.	Stations.	No.	Observed angles.	SECONDS OF—				Logarithms.
				Corr.	Spherical angles.	Spherical excess.	Plane angles and distances.	
15	Humpback	6	15 35 37.229	— .169	2.3			4.0326707 8
	West Base	2	128 33 26.310	+ .973	37.060	.167	36.893	0.5705514 8
	Burke	3	35 50 55.630	+ .529	27.283	.168	27.115	8.8931971 3
16	Humpback	6	32 43 23.447	+ .009	56.159	.167	55.992	9.7676577 7
	West Base	2	79 31 40.980	+ .074	6.3			4.4964193 9
	Tunk	4	67 44 56.530	— .836	6.2			4.3708600 2
17	Humpback	6	14 31 09.048	— .308	2.4			4.1373282 4
	West Base	2	152 41 29.760	— .399	23.456	.268	23.188	0.2671403 0
	Pigeon	5	12 47 21.110	+ 1.515	41.654	.268	41.386	9.9927056 3
18	Humpback	6	17 07 46.218	+ .178	55.694	.268	55.426	9.9663814 9
	Burke	3	44 22 07.010	— .326	6.4			4.3971741 7
	Tunk	4	118 30 08.380	— .875	6.2			4.3708600 3
19	Humpback	6	1 04 28.181	+ .138	2.5			4.4248969 1
	Pigeon	5	1 56 41.360	— .509	08.740	.242	08.498	0.6008430 7
	Burke	3	176 58 51.300	— .397	29.361	.242	29.118	9.6616069 3
20	Humpback	6	18 12 14.399	+ .316	22.625	.241	22.384	9.3451300 6
	Pigeon	5	17 20 16.640	+ .293	6.5			4.6873469 1
	Tunk	4	144 27 29.160	+ .154	6.2			4.3708600 4
21	Humpback	6	5 26 36.898	+ .337	3.4			4.0216623 3
	Burke	3	160 58 42.360	— 1.051	46.396	.195	46.201	0.5308669 2
	East Base	1	13 34 42.400	— .557	06.684	.195	06.489	9.8446449 3
22	Humpback	6	23 17 01.756	— .268	07.505	.195	07.310	9.9438901 5
	Tunk	4	39 21 25.460	+ 1.034	6.4			4.3971741 8
	East Base	1	32 16 26.482	— .062	6.3			4.4964194 0
23	Humpback	6	54 50 40.476	+ .643	5.3			4.2388476 1
	East Base	1	92 52 56.310	— .157	5.3			1.7269369 8
	East Base	1	92 52 56.310	— .157	28.319	.074	28.2952	8.5306408 0
24	Humpback	6	25 10 22.487	+ .451	40.851	.024	40.8260	8.7915683 1
	East Base	1	30 52 00.200	+ .878	50.903	.025	50.8782	4.4964193 9
	Pigeon	5	123 57 37.170	+ .303	6.3			4.6873469 0
25	Humpback	6	32 16 26.482	— .062	6.5			4.6873469 0
	Humpback	6	54 50 40.476	+ .643	5.4			4.4176601 8
	East Base	1	92 52 56.310	— .157	14.715	.321	14.394	0.5052872 9
26	Humpback	6	25 10 22.487	+ .451	16.933	.320	16.613	9.4742267 1
	East Base	1	30 52 00.200	+ .878	29.314	.321	28.993	9.7643994 4
	Pigeon	5	123 57 37.170	+ .303	6.4			4.3971741 8
27	Humpback	6	32 16 26.482	— .062	6.5			4.6873469 1
	Humpback	6	54 50 40.476	+ .643	3.1			4.1389436 4
	East Base	1	92 52 56.310	— .157	37.235	.129	37.106	1.0228807 7
28	Humpback	6	25 10 22.487	+ .451	41.309	.129	41.180	9.5131235 9

Computation of triangle sides—Continued.

No.	Stations.	No.	Observed angles.	SECONDS OF—				Logarithms.
				Corr.	Spherical angles.	Spherical excess.	Plane angles and distances.	
			O I "	"	"	"	"	
25	Mt. Desert.....	7	17 50 24.858	— .605	24.253	.297	23.956	4.0216623 3
	Tunk.....	4	82 40 56.070	+ .651	56.721	.297	56.424	0.5137683 1
	Burke.....	3	79 28 39.150	+ .768	39.918	.298	39.620	9.9926347 2
					7.3			4.5318789 3
					7.4			4.5280653 6
					3.5			4.2584476 1
26	Mt. Desert.....	7	30 36 59.385	+ .788	60.173	.428	59.745	0.2930342 5
	Burke.....	3	59 10 22.540	— .045	22.495	.428	22.047	9.9332499 0
	Pigeon.....	5	90 12 38.140	+ .476	38.616	.428	38.158	9.9999970 7
					7.5			4.4657317 5
					7.3			4.5318789 2
					6.3			4.4364193 9
27	Mt. Desert.....	7	26 49 49.584	— .399	49.185	.749	48.436	0.3454897 1
	Humpback.....	6	29 19 25.597	+ .864	26.461	.750	25.711	9.6899698 2
	Burke.....	3	123 50 46.160	+ .442	46.602	.749	45.853	9.9193529 3
					7.3			4.5318789 2
					7.6			4.7612680 3
					4.5			4.4176691 8
28	Mt. Desert.....	7	48 27 24.243	+ .183	24.426	.624	23.802	0.1258350 5
	Tunk.....	4	56 43 35.290	— .378	34.912	.624	34.288	9.9922365 3
	Pigeon.....	5	74 49 02.860	— .327	02.533	.623	01.910	9.9845701 3
					7.5			4.4657317 6
					7.4			4.5280653 6
					6.4			4.3971741 7
29	Mt. Desert.....	7	8 59 24.726	+ .206	24.932	.257	24.675	0.8061374 1
	Humpback.....	6	12 11 39.379	+ .626	40.065	.257	39.808	9.3247537 7
	Tunk.....	4	158 48 55.550	+ .225	55.775	.258	55.517	9.5579564 4
					7.4			4.5280653 6
					7.6			4.7612680 3
					6.5			4.6873469 1
30	Mt. Desert.....	7	57 26 45.969	+ .389	49.358	1.202	48.156	0.0742284 0
	Humpback.....	6	30 23 53.778	+ 1.002	54.780	1.202	53.578	9.7041564 5
	Pigeon.....	5	92 09 19.500	— .033	19.467	1.201	18.266	9.9996927 2
					7.5			4.4657317 6
					7.6			4.7612680 3
					3.1			4.1383436 4
31	Howard.....	8	11 28 06.015	+ 1.171	07.186	.271	06.915	0.7015166 5
	Burke.....	3	30 19 45.160	— 1.500	43.660	.271	43.389	9.7032572 6
	East Base.....	1	138 12 09.940	+ .026	09.966	.270	09.696	9.8237984 8
					8.1			4.5431175 5
					8.3			4.6630587 6
					5.1			4.3843245 6
32	Howard.....	8	33 30 40.141	+ .204	40.345	.714	39.631	0.2579844 6
	Pigeon.....	5	52 43 54.520	+ .233	54.753	.714	54.039	9.9008085 2
	East Base.....	1	93 45 27.340	— .297	27.043	.713	26.330	9.9999655 1
					8.1			4.5431175 4
					8.5			4.6913745 3
					1.6			4.4893294 3
33	Howard.....	8	17 33 01.364	+ 1.028	02.392	.555	01.837	0.5206457 8
	East Base.....	1	142 29 36.150	— .424	35.726	.554	35.172	9.7845152 5
	Humpback.....	6	19 57 24.016	— .470	23.546	.555	22.991	9.5331423 3
					8.6			4.7044904 5
					8.1			4.5431175 3
					7.1			4.6743540 0
34	Howard.....	8	32 11 14.197	+ .316	14.513	1.148	13.365	0.2735285 8
	Mt. Desert.....	7	23 11 19.990	+ .818	20.808	1.148	19.660	9.5952339 6
	East Base.....	1	124 37 27.540	+ .582	28.122	1.147	26.975	9.9153454 0
					8.1			4.5431175 4
					8.7			4.8632289 8

Computation of triangle sides—Continued.

No.	Stations.	No.	Observed angles.	SECONDS OF—				Logarithms.
				Corr.	Spherical angles.	Spherical excess.	Plane angles and distances.	
			° ' "	"	"	"	"	
35	Howard	8	22 02 34.126	— .968	33.158	.640	32.518	4.2388476 1
	Pigeon	5	86 28 53.550	+ .059	53.609	.641	52.968	0.4256306 0
	Burke	3	71 28 34.660	+ .494	35.154	.640	34.514	9.9991805 4
					8.13			9.9768963 2
					8.15			4.6636587 5
					3.16			4.6413745 3
36	Howard	8	29 01 07.379	+2.199	09.578	1.177	08.401	4.4964193 9
	Burke	3	105 30 16.640	— .891	15.749	1.178	14.571	0.3141690 5
	Humpback	6	45 28 38.895	— .690	38.205	1.177	37.028	9.9839020 1
					8.16			9.8530703 1
					8.13			4.7944904 5
					7.13			4.6636587 6
37	Howard	8	20 43 08.182	— .856	07.320	1.006	06.320	4.5318789 2
	Mt. Desert	7	28 37 56.888	+1.155	58.043	1.006	57.037	0.4512721 3
	Burke	3	130 38 57.200	+ .449	57.649	1.006	56.643	9.6805077 1
					8.13			9.8800779 3
					8.17			4.6636587 6
					5.16			4.8632289 8
38	Howard	8	51 03 41.505	+1.231	42.736	1.794	40.942	4.6873469 1
	Pigeon	5	84 32 12.190	+ .569	12.759	1.793	10.966	0.1091211 1
	Humpback	6	44 24 10.714	— .828	09.886	1.794	08.092	9.9980224 4
					8.16			9.8449065 2
					8.15			4.7944904 6
					5.17			4.6413745 3
39	Howard	8	1 19 25.944	— .112	25.832	.062	25.7699	4.4657317 6
	Pigeon	5	176 41 31.690	+ .535	32.225	.063	32.1620	1.6363307 0
	Mt. Desert	7	1 59 02.427	— .307	02.130	.062	02.0681	8.7611615 2
					8.17			8.5303120 7
					8.15			4.8632289 8
					7.16			4.6413745 3
40	Howard	8	49 44 15.561	+1.344	16.905	2.933	13.972	4.7612680 3
	Mt. Desert	7	55 27 46.472	+ .756	47.228	2.933	44.295	0.1174252 2
	Humpback	6	74 48 04.492	+ .174	04.666	2.933	01.733	9.9157972 0
					8.16			9.9157972 0
					8.17			9.9845357 3
					3.16			4.7944904 5
41	Cooper	9	32 00 62.260	—1.165	61.095	1.389	59.706	4.8632289 8
	Burke	3	62 44 36.700	—1.178	37.878	1.389	36.489	4.6413745 3
	Humpback	6	85 14 25.280	— .085	25.195	1.390	23.805	4.4964193 9
					9.16			0.2755891 8
					9.13			9.9488846 3
					7.13			9.9984995 1
42	Cooper	9	2 24 39.965	— .063	39.902	.194	39.7075	4.7208932 0
	Mt. Desert	7	4 10 44.694	+ .467	45.161	.195	44.9665	4.7705080 8
	Burke	3	173 24 37.140	—1.620	35.520	.194	35.3260	4.9677442 4
					9.13			4.7705080 8
					9.17			4.6636587 6
					8.13			0.1079183 8
43	Cooper	9	51 15 31.369	+ .578	31.947	1.559	30.388	9.9989309 5
	Howard	8	85 58 53.870	+ .990	54.860	1.560	53.300	9.8318250 1
	Burke	3	42 45 39.940	—2.069	37.871	1.559	36.312	4.7705080 8
					9.13			4.6034021 4
					9.18			4.7612680 3
44	Cooper	9	34 25 42.225	—1.228	40.997	2.333	38.664	0.2476736 8
	Mt. Desert	7	31 00 34.278	+ .069	34.347	2.333	32.014	9.7119515 0
	Humpback	6	114 33 50.877	+ .779	51.656	2.334	49.322	9.9528025 4
					9.16			4.7208932 1
					9.17			4.9677442 5

Computation of triangle sides—Continued.

No.	Stations.	No.	Observed angles.	SECONDS OF—				Logarithms.
				Corr.	Spherical angles.	Spherical excess.	Plane angles and distances.	
			c " "	"	"	"	"	
45	Cooper	9	83 16 33.629	— .587	33.042	1.772	31.270	4.7944904 5
	Howard	8	56 57 46.491	—1.209	45.282	1.771	43.511	0.0029881 1
	Humpback	6	39 45 46.385	+ .605	46.990	1.771	45.219	9.9234046 4
					9.6			9.8059135 7
46					9.6			4.7208932 0
					9.8			4.6034021 4
					8.7			4.8632280 8
	Cooper	9	48 50 51.404	+ .641	52.045	2.371	49.674	0.1232301 2
	Howard	8	106 41 62.052	+ .134	62.186	2.371	59.815	9.9812851 5
	Mt. Desert	7	24 27 12.194	+ .688	12.882	2.371	10.511	9.6169430 4
					9.7			4.9677442 5
					9.8			4.6034021 4

(16.) Resulting distance from Mt. Desert to Humpback.

The logarithmic difference between the base and the primary triangle side, Mt. Desert–Humpback, is, accordingly, 0.8209536 9. It may also be stated that a seven-place computation, using the principal corrections only, as given in art. 13, gave for the above difference 0.8209537.

If we use the ten-place computation, we find the logarithmic length of the side, independently, from four triangles, as follows:

	4.7612680	279	
		300	
		318	
		310	
			<i>mc</i>
Mean,	4.7612680	302	number = 57712.253
log. base,	3.9403143	416	
log. difference,	0.8209536	886	

The consideration of the probable error of the derived side, Mt. Desert–Humpback, will be reserved for a subsequent communication.

(17.) Connexion of the azimuth mark with the adjusted directions.

The direction of the azimuth mark requires a small change, due to the adjustment of the geometrical figure of the triangulation, so as to make it dependent upon all the directions at each station. It was done as follows: The angular difference of the mark and each direction, as resulting from the abstract of results given in art. 5, was again applied to the adjusted angles, (the sign being reversed,) each direction furnishing a result of the reading of the azimuth mark; the indiscriminate mean, without regard to weights, was taken for the final value, and inserted in the preceding table of results, art. 14.

Thus for Humpback we have (omitting here degrees and minutes):

	Difference.	Azimuth mark.
	"	"
Cooper	+ 40.230	40.230
Howard	— 06.155	.825
East Base	— 30.171	.365
West Base	— 07.821	.314
Pigeon	— 16.869	.007
Burke	— 45.050	.145
Tunk	— 31.268	.323
Desert	— 10.647	.009
	Mean	40.403 ± 0."081

The former probable error (art. 5) was $\pm 0.''163$, which, combined with $\pm 0.''081$, gives the final probable error.....	$\pm 0.''182$
Similarly for Mt. Desert	$\pm 0.''134$
Similarly for Howard.....	$\pm 0.''221$
Similarly for Cooper.....	$\pm 0.''229$

Considering the change in the initial direction at each station, the change produced by the above process amounts only to a few hundredths of a second.

The adjustment of the adjoining triangulation will yet exert a small influence upon the azimuthal directions of Mt. Desert and Humpback, also upon Howard and Cooper.

APPENDIX No. 15.

LIST OF GEOGRAPHICAL POSITIONS DETERMINED BY THE UNITED STATES COAST SURVEY, AND CONTINUED FROM REPORTS OF 1851, 1853, 1855, 1857, AND 1859.

The present list is a continuation of that published in the annual reports for 1851, 1853, 1855, 1857, and 1859, and contains the geographical positions of points determined astronomically and trigonometrically since the date of the former reports, with the repetition of a few points previously published, for convenience of reference. The present publication, however, is limited to positions on the northern and western coasts. Those on the southern coast are also prepared in manuscript, but their publication at present is not deemed expedient. The following explanations will give all the information required for the use of the tables:

For the purposes of the survey the coast is divided into eleven sections, in all of which the work is carried on simultaneously. The survey being in different stages of progress in the several sections, and new results being added from year to year to those here given, the same divisions have been adopted in the publication.

The several sections are defined as follows:

Section I. From Passamaquoddy bay to Point Judith.

Section II. From Point Judith to Cape Henlopen.

Section III. From Cape Henlopen to Cape Henry.

Section IV. From Cape Henry to Cape Fear.

Section V. From Cape Fear to St. Mary's river.

Section VI. From St. Mary's river to St. Joseph's bay.

Section VII. From St. Joseph's bay to Mobile bay.

Section VIII. From Mobile bay to Vermilion bay.

Section IX. From Vermilion bay to the Rio Grande.

Section X. Coast of California, San Diego bay, to 42d parallel.

Section XI. Coast of Oregon and Washington Territory, 42d to 49th parallel.

The tables give the latitudes and longitudes of the trigonometrical points in each section, and their relative azimuths or bearings and distances. The manner in which these data have been obtained may be briefly explained here.

In each section a base line of from five to ten miles is measured with all possible accuracy. A series of triangles, deriving the length of their sides from this base, is then established along the coast by the measurement of the angles between the intervisible stations. In this primary series the triangles are made as large as the nature of the country will permit, because the liability to error increases with the number of triangles.

On the bases furnished by the sides of the primary triangles a secondary triangulation is next established, extending along the coast and over the smaller bays and sounds, and determining a large number of points at distances a few miles apart for the use of the topographical and hydrographical surveys.

The distances between the points thus determined, as given in the tables, are liable to an average error of about one foot in six miles, until a final adjustment between the base lines shall have been made.

In some parts of the survey the base lines for the primary triangulations have not yet been measured,

or the connexion between the secondary and primary triangulation has not yet been made; in which cases the distances depend on preliminary base lines, measured with great care, and they are liable to an average error of one foot in three miles.

As, on the completion of the primary or main triangulation in each section, the several series form one connected chain, the different bases afford verifications of each other and of the triangulation connecting them. The first four sections are thus connected; the last section and part of the fifth, however, only in a preliminary way.

Observations for latitude and azimuth are made at a number of stations of the primary triangulation in each section. The differences of latitude, longitude, and azimuth between these and other stations are then computed, under the supposition that the earth is a spheroid of revolution of the following dimensions, which are those determined by Bessel from the reliable measurements made at the time, viz:

Equatorial radius	= 6377397.16 metres.
Polar radius	= 6356078.96 metres.
Eccentricity	= 0.08169683.

It has been found that the differences of latitude and longitude, as computed in this manner, from the distance and azimuth between two stations, and which are called geodetic, differ from those which are obtained by astronomical observations at the several stations by quantities which are greater than the errors of the observations. Such disagreements are due to local irregularities in the figure and density of the earth, and the error resulting from them in the determinations of latitude and of the meridian plane is designated as station error. It amounts, according to the results obtained at present, to between one and four seconds of arc in the eastern section of the survey, and to about one second and a half in the sections south of the Delaware.

In order to eliminate the influence of station errors on the general result, observations are made at a number of stations, the results are referred to a central station by means of the geodetic differences, and the mean of all is used for the computation of the positions given in the tables. The geographical positions must therefore be considered as liable to future changes from the accumulation of new observations and from the final discussion of all the results obtained.

The *differences of longitude* are obtained, as has been stated, by computation from the distances, latitudes, and azimuths of the triangulation. In adding up the differences from station to station, an accumulation of the incidental errors is probable. They are checked, however, by differences of longitude, determined by means of the electro-magnetic telegraph in every section where the introduction of the latter makes it practicable.

Seaton station, in Washington city, has been selected as the centre for the telegraphic differences of longitude. The sections at present connected by telegraph are Sections I, II, III, IV, V, VII, and VIII. The first three being also connected by primary triangulation, the check on the geodetic differences of longitude is here obtained, and the agreement is very close. The longitudes from Greenwich in the first five sections depend directly, and in other sections indirectly, upon that of Cambridge observatory, as determined by chronometric differences between Liverpool and Cambridge, and by occultations, eclipses, and moon culminations observed at various observatories in the United States, and referred to Cambridge by means of telegraphic differences.

The longitude of Cambridge, Harvard observatory, as adopted in former reports, (since 1851,) viz: *4h. 44m. 29.5s.*, or $71^{\circ} 07' 22.50''$, is, for uniformity's sake, still retained. From later discussions it would seem to bear an increase of about three-quarters of a second of time.

The longitude in Section X is reckoned from Greenwich. It depends on moon culminations observed at San Diego, Point Conception, Point Pinos, Presidio, Telegraph Hill, Port Orford, Cape Disappointment, and Cape Flattery, compared with corresponding observations at Greenwich and American observatories, and on chronometric differences between the same and other stations.

In Section X the longitude of Presidio observatory, San Francisco, has been adopted— $122^{\circ} 26' 15.0''$.

EXPLANATION OF THE TABLES.

The first column on the left contains the name of the several stations or triangulation points. Their general locality is indicated by the heading at the top of the page, by means of which they may be readily found on the sketches accompanying the tables. Sub-headings in the first column indicate the locality more minutely where it is practicable.

The stations are generally either prominent objects of permanence, such as spires, light-houses, beacons, &c., or they are points on prominent hills, capes, and points of land, where signals have been erected for the purposes of the survey, and which are marked on the ground. In a small number of cases in the first three sections, but much more frequently in the southern sections, where settlements on the coast are sparse and few permanent objects are to be found, the stations have no other distinguishing mark than the signal erected on the spot, and, after its decay, the mark left in the ground to designate the station point. The latter generally consists of posts or stones set around the point, while the centre of the station is designated by an earthen cone or glass bottle buried under the surface of the ground, and marked on the top by a stone or post. Where the station is on a rock, a copper bolt, or hole filled with lead or sulphur, will be found to designate the exact spot.

The sketches showing the configuration of the land, as well as the relative positions of the stations, no great difficulty will be experienced in finding the latter when desired for local surveys or reference. In any case where minute descriptions of particular points are required, they can be had by application addressed to the Coast Survey office.

The second and third columns contain the latitudes and longitudes of the stations named.

The fourth column contains the azimuth of the line joining the station named in the first column with that named in the fifth; that is to say, the angle which that line makes with the meridian of the former station, reckoned from south around by west through the whole circle.

The sixth column gives the back azimuth of the same line, or the angle which it makes with the meridian of the latter station, reckoned as before; the difference between the azimuths in the fourth and those in the sixth column being 180° , less the inclination of the meridians at the two stations.

The seventh, eighth, and ninth columns give the distances in metres, yards, and miles between the stations named in the first and fifth columns. The relation of the metre to the yard used in obtaining these results is: 1 metre = 1.0935696 yards, or 39.368505 United States standard inches.

For each station the azimuths and distances to two other stations are given. In every case the lines so given have actually been observed.

In each section the stations of the primary triangulation are distinguished by being printed in SMALL CAPITALS.

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Passamaquoddy Bay and St. Croix River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	<i>Metres.</i>	<i>Yards.</i>	<i>Miles.</i>
COOPER	44 59 12.33	67 27 39.74	40 44 03 75 09 44	Mount Desert..... Humpback	220 12 00 254 42 28	92841.0 52582.2	101528.1 57508.9	57.69 32.68
HOWARD	44 37 45.31	67 23 22.85	114 58 26 65 14 09	Humpback	294 28 15	62290.9	68129.3	38.71
GRAND MANAN.....	44 44 52.31	66 49 30.40	73 47 18 118 04 11	Mount Desert..... Howard	244 39 12 253 23 29	72983.5 46648.6	79812.5 51013.5	45.35 28.98
CHAMCOOK.....	45 07 29.13	67 04 38.96	334 28 27 63 13 19	Cooper	297 37 16	50830.5	62148.1	35.31
Prince Regent's Redoubt.....	44 55 10.25	67 00 17.15	101 53 11 165 55 10	Grand Manan..... Cooper	154 39 09 242 57 02	46375.6 33877.9	50714.9 37047.8	28.81 21.05
Trescott Rock	44 45 31.02	67 06 08.28	57 50 43 203 17 49	Chamcook	345 52 05	23515.9	25716.3	14.61
Arcus	44 54 11.16	67 11 11.28	237 38 36 23 21 57	Howard	237 38 36	26432.2	29452.2	16.74
Porcupine	44 49 19.87	67 00 52.35	262 41 25 337 27 18	Prince Regent's Redoubt..... Trescott Rock	23 21 57 157 30 51	19470.2 17378.6	21292.0 19004.7	12.09 10.80
Perry Pigeon.....	44 57 05.33	67 03 13.91	123 48 42 43 59 31	Prince Regent's Redoubt..... Trescott Rock	82 49 07 303 41 30	14462.6 16182.2	15815.8 17626.4	8.99 10.05
Hannah	44 58 04.02	66 57 31.30	348 17 22 312 29 30	Arcus	223 55 52	9813.1	10731.3	6.10
Hannabury.....	44 56 17.75	66 54 48.08	168 18 58 132 31 35	Porcupine	168 18 58	14671.5	16044.3	9.12
Friar's Head	44 52 33.65	66 57 57.83	76 28 06	Prince Regent's Redoubt..... Perry Pigeon.....	132 31 35 214 06 42	5256.8 6479.6	5742.6 7085.9	3.27 4.03
Foster	44 55 29.27	67 06 46.08	97 36 15 73 53 57	Perry Pigeon.....	256 24 04	7723.5	8446.2	4.80
Quoddy	44 48 50.73	66 57 25.74	140 27 08 147 42 30	Prince Regent's Redoubt..... Prince Regent's Redoubt.....	277 30 18 253 50 05	11171.9 7497.6	12217.3 8199.1	6.94 4.66
Bishop	44 47 55.77	66 46 26.76	326 07 26 237 32 18	Perry Pigeon.....	320 23 25	10880.0	11898.0	6.76
Wolf	44 56 11.59	66 43 42.39	61 49 48 118 42 11	Prince Regent's Redoubt..... Porcupine	327 40 52	5719.0	6254.1	3.55
White Horse.....	44 59 30.43	66 51 58.28	96 44 56 142 13 37	Perry Pigeon.....	146 11 32	13727.7	15012.2	8.53
Denboe	44 52 51.89	67 05 20.17	53 06 02 100 53 39	Porcupine	57 34 48	5527.0	6044.2	3.43
Raccoon	44 54 42.59	66 56 11.66	32 07 50 89 56 46	Perry Pigeon.....	241 43 41	13035.2	14254.9	8.10
Treat	44 52 43.15	66 59 03.20	237 15 05 107 39 14	Trescott Rock	298 32 29	20646.0	22577.9	12.83
Indian Island.....	44 56 13.78	66 57 48.31	202 56 21 280 43 53	Quoddy	276 37 12	14578.8	15942.9	9.06
Marvel	44 55 13.05	66 57 50.92	32 07 50 89 56 46	Hannah	322 05 48	23771.8	25990.2	14.77
East Quoddy Light	44 57 27.91	66 53 39.56	102 23 50 280 08 37	Quoddy	232 56 21	22619.6	24736.1	14.06
White Island Ledge.....	44 58 54.23	66 53 47.01	290 41 15 72 30 37	Hannabury.....	280 43 53	18495.3	20225.9	11.49
Bar Island.....	44 58 21.41	66 56 28.97	32 07 50 89 56 46	Quoddy	232 56 21	22619.6	24736.1	14.06
Hybernia Cove	44 57 23.83	66 57 29.16	237 15 05 107 39 14	Hannabury.....	212 05 50	7022.4	7679.5	4.36
Indian Point.....	44 50 02.34	66 56 50.05	30 21 03 211 46 12	Hannabury.....	249 52 51	7767.1	8493.9	4.83
Owen	44 49 49.88	66 55 17.59	237 15 05 107 39 14	Prince Regent's Redoubt..... Arcus	57 18 39 287 35 06	7901.0 8082.6	8640.3 8838.8	4.91 5.02
Comstock, (2)	44 53 11.16	67 00 50.94	19 32 12 76 30 35	Friar's Head	210 19 48	4611.4	5042.9	2.87
Roger	44 52 09.70	66 59 56.90	281 32 42 156 33 59	Hannabury.....	31 47 11	3475.2	3778.5	2.15
			241 38 06 300 05 25	Prince Regent's Redoubt..... Friar's Head	340 19 49 101 33 28	4821.7 1464.1	5272.9 1601.1	3.00 0.91
			268 12 02 59 00 57	Friar's Head	88 14 09	3940.0	4308.7	2.45
			1 45 56 88 28 08	Prince Regent's Redoubt..... Friar's Head	238 59 12	3807.4	4163.7	2.37
			102 23 50 280 08 37	Prince Regent's Redoubt..... Friar's Head	181 45 51 268 26 25	4922.5 3207.9	5383.1 3508.0	3.06 1.99
			290 41 15 72 30 37	Hannabury.....	282 21 06	5199.2	5685.7	3.23
			330 03 10 23 49 24	Wolf	109 15 39	13299.5	14543.9	8.26
			241 38 06 300 05 25	Hannabury.....	110 48 22	14168.9	15494.6	8.80
			19 32 12 76 30 35	Hannabury.....	252 27 59	5153.2	5635.4	3.20
			82 58 53 285 45 19	Indian Island.....	150 04 21	4404.6	4816.7	2.74
			330 42 42 156 33 59	White Horse.....	203 48 28	4306.1	4709.0	2.68
			254 11 49 175 26 54	Hannabury.....	61 42 00	8235.1	9005.7	5.12
				Quoddy	120 07 18	4066.3	4446.8	2.53
				Porcupine	199 31 47	2345.3	2564.7	1.46
				Porcupine	256 27 40	5609.1	6134.0	3.49
				Bishop	262 54 53	7541.5	8247.1	4.69
				Quoddy	106 51 33	12182.5	13322.4	7.57
				Perry Pigeon.....	150 45 07	9214.6	10076.8	5.73
				Friar's Head.....	336 32 18	7878.5	8615.7	4.90
				Prince Regent's Redoubt.....	74 13 13	2715.4	2969.5	1.69
					355 26 40	5590.7	6113.8	3.47

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Section I.—Passamaquoddy Bay and St. Croix River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	Meters.	Yards.	Miles.
West Quoddy Light.....	44 48 53.71	66 56 40.96	231 34 46 277 29 15	Wolf..... Bishop.....	51 43 55 97 36 28	21785.4 13613.6	23823.9 14887.7	13.54 8.46
Herring Cove, flag in tree.....	44 52 36.46	66 54 33.91	177 15 43 28 26 36	Hannabury..... Quoddy.....	357 15 32 208 24 35	6836.2 7920.5	7475.9 8661.6	4.25 4.92
Beech, flag in tree.....	44 56 59.05	66 58 39.57	216 42 44 91 52 24	Hannah..... Perry Pigeon.....	36 43 32 271 49 10	2502.1 6015.8	2736.2 6578.7	1.55 3.74
North Head.....	45 01 23.37	66 56 33.10	11 42 39 346 21 30	Hannah..... Hannabury.....	191 41 58 166 22 44	6384.1 9707.0	6872.1 10615.3	3.90 6.03
Anley.....	45 03 04.22	66 52 20.70	60 37 08 355 45 03	North Head..... White Horse.....	240 34 09 175 45 19	6340.4 6616.4	6933.6 7235.5	3.94 4.11
Navy.....	45 03 16.70	67 02 17.82	294 50 24 158 24 23	North Head..... Chamecock.....	114 54 28 338 22 43	8315.8 8380.6	9093.9 9164.8	5.17 5.21
Shortland.....	45 05 25.50	67 08 50.19	235 10 43 334 28 18	Chamecock..... Perry Pigeon.....	55 13 41 154 32 16	6687.0 17104.0	7312.7 18704.4	4.15 10.63
Pembroke.....	44 57 44.71	67 11 44.08	287 30 05 302 38 33	Prince Regent's Redoubt..... Foster.....	107 38 10 122 42 03	15735.4 7744.5	17273.4 8469.1	9.81 4.81
Yellow House, chimney.....	44 55 38.50	67 07 06.05	303 49 46 335 41 02	Foster..... Denboe.....	123 50 00 153 42 17	511.5 5642.8	559.3 6170.8	0.32 3.51
Kendall.....	44 55 57.10	67 00 33.85	84 02 26 345 46 58	Foster..... Prince Regent's Redoubt.....	263 58 02 103 47 10	8220.0 1491.8	8989.1 1631.4	5.11 0.93
Eastport, Unitarian church.....	44 54 10.11	66 58 58.51	103 25 58 335 53 58	Foster..... Friar's Head.....	283 20 27 155 54 41	10555.0 3262.0	11542.7 3567.2	6.56 2.03
Esty.....	44 53 31.97	66 59 30.01	311 39 43 143 18 59	Friar's Head..... Perry Pigeon.....	131 40 48 323 16 21	2707.6 8214.4	2960.9 8983.0	1.68 5.10
Red Island, flag in tree.....	44 54 44.14	67 04 34.83	115 43 33 261 51 07	Foster..... Prince Regent's Redoubt.....	295 42 00 81 54 09	3209.0 5708.4	3509.2 6242.5	1.99 3.55
Gould's House.....	44 54 10.75	67 03 11.02	117 09 16 179 19 33	Foster..... Perry Pigeon.....	297 06 44 359 19 31	5314.7 5389.1	5812.0 5893.4	3.30 3.35
Seward's Neck, tall pine.....	44 53 23.14	67 02 36.54	173 11 17 222 45 07	Perry Pigeon..... Prince Regent's Redoubt.....	353 10 51 42 46 45	6907.0 4503.2	7533.3 4921.6	4.29 2.80
Tall Pine.....	44 51 06.45	67 03 39.26	153 08 12 250 12 48	Foster..... Friar's Head.....	333 06 00 70 16 49	9095.0 7963.0	9946.0 8708.1	5.65 4.95
Busby-top Tree.....	44 50 19.53	67 03 38.12	156 37 17 154 31 41	Foster..... Denboe.....	336 35 04 334 30 29	10416.2 5210.1	11390.9 5697.6	6.47 3.24
Little.....	44 51 09.06	67 09 14.83	287 07 41 155 33 39	Porcupine..... Arcus.....	107 13 31 335 32 17	11412.4 6174.2	12480.2 6751.9	7.09 3.84
North end of Spruce Island.....	44 58 29.42	66 53 55.70	80 35 39 233 46 52	Hannah..... White Horse.....	260 33 07 53 48 15	4786.4 3188.8	5234.3 3487.2	2.97 1.98
Cape Leprean Light.....	45 03 29.15	66 27 10.62	41 27 33 76 02 51	Bishop..... Hannah.....	221 13 57 255 41 23	38374.7 41106.3	41965.4 44952.6	23.84 25.54
Chimney of house on Sand Island..	44 58 30.98	66 54 28.66	82 33 48 236 55 10	Hannah..... White Horse.....	262 31 39 56 56 56	4036.0 3930.1	4413.7 4297.8	2.51 2.44
South end of Spruce Island.....	44 58 10.00	66 54 16.58	87 32 42 11 28 49	Hannah..... Hannabury.....	267 30 24 191 28 26	4270.8 3535.4	4670.4 3866.2	2.65 2.20
East end of Casco Island.....	44 57 23.27	66 55 21.56	55 56 06 216 42 51	Indian Island..... White Island Ledge.....	235 54 22 36 43 58	3884.1 3465.0	4247.6 3789.2	2.41 2.15
Herring, (hyd.).....	44 57 06.90	66 54 36.23	114 42 01 217 58 13	Hannah..... White Horse.....	294 39 57 38 00 05	4222.3 5621.6	4617.4 6147.6	2.62 3.49
Casco Island, flag in tree.....	44 57 14.63	66 55 47.93	54 33 48 123 57 01	Indian Head..... Hannah.....	234 32 23 303 55 48	3239.0 2730.5	3542.0 2985.9	2.01 1.70
Johnnie.....	44 56 38.18	66 55 21.95	133 04 41 76 48 05	Hannah..... Indian Island.....	313 03 10 256 46 22	3880.2 3295.8	4243.3 3604.1	2.41 2.05
Green Island.....	44 56 56.14	66 56 17.01	142 09 33 229 56 04	Hannah..... White Horse.....	322 08 41 49 59 07	2633.5 7403.5	2901.8 8096.2	1.65 4.60
Pope's Folly.....	44 56 40.39	66 56 49.71	11 06 19 160 32 59	Friar's Head..... Hannah.....	191 05 31 340 32 30	7761.6 2737.1	8487.8 2993.2	4.82 1.70
Eastport, Congregationalist church.	44 54 14.99	66 58 54.03	133 05 58 338 28 47	Prince Regent's Redoubt..... Friar's Head.....	313 04 59 158 29 27	2496.6 3362.3	2730.2 3676.9	1.55 2.09
Fort Sullivan, flagstaff.....	44 54 25.23	66 58 55.04	127 39 50 339 58 13	Prince Regent's Redoubt..... Friar's Head.....	307 38 52 159 58 53	2274.8 3665.6	2487.6 4008.6	1.41 2.28
Moses House, west chimney.....	44 55 23.76	66 57 36.23	245 35 11 5 09 37	Hannabury..... Friar's Head.....	65 37 09 185 09 22	4034.0 5272.1	4411.5 5765.4	2.51 3.28

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Section I.—Passamaquoddy Bay and St. Croix River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	<i>Meters.</i>	<i>Yards.</i>	<i>Miles.</i>
Campobello Island, (B.).....	44 54 08.00	66 57 02.21	22 44 39 123 55 17	Friar's Head..... Perry Pigeon.....	202 44 00 303 50 55	3157.6 8917.7	3453.0 9752.1	1.96 5.54
East Beacon.....	44 49 48.99	66 57 26.59	79 05 22 359 24 27	Porcupine..... Quoddy.....	256 02 53 179 24 28	4737.1 1797.9	5180.4 1966.1	2.94 1.12
Carrying Place Church.....	44 48 36.52	66 58 54.33	189 36 54 257 16 49	Friar's Head..... Quoddy.....	9 37 34 77 17 51	7423.8 1995.1	8118.5 2181.8	4.61 1.24
Woodard's Point.....	44 50 11.99	66 59 00.15	58 13 34 330 24 22	Porcupine..... Quoddy.....	238 12 11 140 25 29	2054.0 3234.4	3339.8 3558.9	1.90 2.02
Lubec Church.....	44 51 37.29	66 58 54.70	339 10 59 164 37 12	Quoddy..... Prince Regent's Redoubt.....	159 12 02 344 36 14	5499.3 6817.6	6013.9 7455.5	3.42 4.24
Signal Flagstaff.....	44 51 39.92	66 58 55.36	150 34 30 217 16 47	Perry Pigeon..... Friar's Head.....	330 31 27 37 17 28	11534.5 2053.8	12613.8 2278.8	7.17 1.29
Lizard Signal.....	44 52 18.94	66 59 11.60	254 19 30 126 29 12	Friar's Head..... Comstock, (2).....	74 20 22 306 28 02	1681.5 2711.2	1838.8 2964.9	1.04 1.68
Mark Island, flag in tree.....	44 52 04.72	66 58 42.79	159 18 57 227 51 15	Treat..... Friar's Head.....	339 18 43 47 51 47	1267.8 1330.7	1386.4 1455.2	0.79 0.83
Plaster Mill, chimney.....	44 51 31.63	67 00 20.10	238 28 45 180 32 53	Friar's Head..... Prince Regent's Redoubt.....	58 30 25 0 32 55	3602.7 6748.3	4005.5 7379.8	2.28 4.19
Pole on hill.....	44 52 33.39	67 00 50.79	188 39 47 209 51 38	Prince Regent's Redoubt..... Friar's Head.....	8 40 11 89 53 40	4897.7 3795.8	5356.0 4150.9	3.04 2.36
Comstock, (1).....	44 52 49.40	67 00 44.03	167 12 42 274 58 45	Comstock, (2)..... Treat.....	347 12 37 94 59 56	688.8 2222.3	753.2 2430.2	0.43 1.38
Chimney of small Baptist church.....	44 52 53.88	67 01 00.81	201 32 40 314 17 44	Comstock, (2)..... Roger.....	21 32 47 134 18 29	573.5 1952.5	627.1 2135.2	0.36 1.21
Shackford.....	44 54 00.55	67 00 37.73	307 22 59 149 02 00	Friar's Head..... Perry Pigeon.....	127 24 52 329 00 10	4416.4 6652.5	4829.6 7274.9	2.74 4.13
Tinker's Island, flag.....	44 58 28.45	66 55 03.70	244 45 06 40 58 23	White Horse..... Indian Island.....	64 47 17 220 56 27	4489.3 5503.9	4909.4 6018.9	2.79 3.42
Spectacle Island, flag.....	44 59 09.16	66 54 41.60	259 34 30 37 06 09	White Horse..... Indian Island.....	79 36 25 217 03 57	3636.5 6785.5	3976.8 7420.4	2.26 4.22
Hannabury Tree.....	44 56 31.56	66 54 47.74	2 45 14 95 24 56	Hannabury..... Perry Pigeon.....	182 45 13 275 18 52	426.8 11143.9	466.7 12186.7	0.26 6.92
White Head.....	45 01 21.42	66 51 31.17	9 50 51 24 47 54	White Horse..... Hannabury.....	189 50 32 204 45 34	3476.5 16323.7	3801.8 17289.6	2.16 6.41
Hospital Island.....	44 59 19.44	66 54 31.66	264 12 33 36 57 45	White Horse..... Indian Island.....	84 14 21 216 55 26	3375.9 7170.1	3691.8 7841.0	2.10 4.46
Nubble.....	44 59 34.24	66 54 01.21	9 44 06 38 49 57	Hannabury..... Indian Island.....	189 43 33 218 47 17	6153.5 7940.5	6729.3 8683.5	3.82 4.93
Pleasant Point Church.....	44 57 21.12	67 02 02.91	27 30 59 72 37 35	Denbee..... Perry Pigeon.....	207 28 40 252 36 45	9362.9 1668.5	10245.5 1824.6	5.82 1.04
Pleasant Point, flagstaff.....	44 57 26.26	67 02 05.41	178 33 41 66 43 06	Navy..... Perry Pigeon.....	358 33 32 246 42 18	10820.1 1633.9	11832.5 1786.8	6.72 1.02
Leighton's House, chimney.....	44 52 47.99	67 05 24.65	199 50 10 219 17 13	Perry Pigeon..... Denbee.....	19 51 42 39 17 16	8444.7 155.3	9234.8 169.8	5.25 0.10
Clam Cove.....	44 57 57.47	67 00 46.41	352 54 46 63 33 01	Prince Regent's Redoubt..... Perry Pigeon.....	172 55 07 243 31 17	5200.8 3610.7	5687.5 3948.6	3.23 2.24
Herring Cove, white rock.....	44 52 30.86	66 54 27.55	308 45 29 29 57 23	Bishop..... Quoddy.....	128 51 08 209 35 17	13549.3 7840.4	14817.1 8574.0	8.42 4.87
West Beacon.....	44 50 20.35	66 58 08.92	63 29 27 287 47 21	Porcupine..... Indian Point.....	243 20 28 107 48 17	4163.2 1819.2	4552.7 1929.5	2.59 1.13
Liberty Point, flag in tree.....	44 49 55.71	66 55 32.97	81 14 05 96 53 46	Porcupine..... Indian Point.....	261 10 16 276 52 52	7281.7 1705.4	7963.1 1865.0	4.52 1.06
Liberty Point Ledge.....	44 49 40.04	66 55 47.22	54 53 39 116 31 11	Quoddy..... Indian Point.....	234 52 29 286 30 27	2645.8 1542.0	2893.3 1686.3	1.64 0.96
West Bliss.....	45 01 27.52	66 50 26.65	29 03 12 56 00 19	White Horse..... Hannah.....	209 02 07 235 55 19	4133.2 11223.1	4519.9 12273.3	2.57 6.97
East Bliss.....	45 02 03.14	66 49 14.33	37 19 01 114 49 29	White Horse..... Anley.....	217 17 05 294 47 17	5994.9 4493.1	6479.3 4913.5	3.68 2.79
Caillif.....	45 02 54.02	66 49 54.49	95 38 22 72 15 18	Anley..... North Head.....	275 36 38 252 10 36	3214.6 9161.7	3515.4 10019.0	2.00 5.69
Deadman Head.....	45 02 30.66	66 46 32.80	52 03 24 97 46 56	White Horse..... Anley.....	231 59 33 277 42 50	9040.1 7682.7	9886.0 8401.6	5.62 4.77

REPORT OF THE SUPERINTENDENT OF
UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I—Passamaquoddy Bay and St. Croix River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	<i>Metres.</i>	<i>Yards.</i>	<i>Miles.</i>
Pea Point	45 02 30.56	66 47 52.19	100 03 26 79 44 33	Anley	280 00 16	5986.6	6524.9	3.71
				North Head	259 38 24	11588.1	12572.4	7.20
Mascabin	45 02 19.00	66 53 05.80	36 28 43 69 17 39	Hannah	216 25 35	9783.8	10699.3	6.08
				North Head	249 15 05	4851.0	5304.9	3.01
Barns	45 00 09.74	66 53 40.49	197 57 34 298 27 02	Anley	17 58 30	5661.5	6191.2	3.52
				White Horse	118 28 14	2545.3	2783.5	1.58
Mowatt	44 59 58.01	66 54 06.65	201 57 59 7 43 13	Anley	21 59 14	6198.1	6778.1	3.85
				Hannabury	187 42 43	6860.5	7502.4	4.26
Simpson	44 59 55.88	66 54 29.46	134 56 36 253 19 31	North Head	314 55 09	3823.6	4181.3	2.38
				White Horse	103 21 18	3402.0	3720.3	2.11
Adam	45 00 48.66	66 54 04.07	208 23 16 6 40 13	Anley	28 24 29	4756.7	5201.8	2.96
				Hannabury	186 39 42	8418.7	9206.4	5.23
Fish	45 00 35.42	66 55 14.27	295 01 47 130 37 45	White Horse	115 04 05	4736.7	5179.9	2.94
				North Head	310 36 49	2273.4	2486.1	1.41
Mink	44 59 27.05	66 55 47.70	164 31 34 268 46 34	North Head	344 31 02	3725.2	4073.8	2.31
				White Horse	88 49 16	5025.6	5495.8	3.12
St. Helena	44 59 22.23	66 56 12.19	35 41 00 173 01 35	Hannah	215 40 04	2971.4	3249.4	1.85
				North Head	353 01 20	3767.0	4119.5	2.34
Mowe	44 59 35.44	66 56 51.82	187 01 15 17 02 44	North Head	7 01 28	3357.3	3671.5	2.08
				Hannah	197 02 16	2951.5	3227.6	1.83
Higgins	44 59 52.39	66 55 47.57	34 12 12 160 27 54	Hannabury	214 10 59	4043.3	4421.6	2.51
				North Head	340 27 22	2980.0	3258.8	1.85
Hardwood	45 00 58.45	66 55 15.94	302 05 38 114 29 13	White Horse	122 07 58	5109.1	5587.2	3.17
				North Head	294 28 18	1855.9	2029.6	1.15
Graveyard	45 00 59.94	66 55 47.85	22 39 28 298 46 11	Hannah	202 38 15	5883.7	6434.2	3.66
				White Horse	118 48 54	5735.6	6272.3	3.56
Butler	45 01 12.24	66 56 12.28	348 36 01 235 41 11	Hannabury	168 37 00	9272.6	10140.2	5.76
				Anley	55 43 53	6134.7	6708.7	3.81
Chimney of white house, with white roof.	45 04 38.11	66 54 25.31	316 44 21 1 54 00	Anley	136 45 49	3978.2	4350.5	2.47
				Hannabury	181 53 43	15433.1	16899.1	9.60
Hoy	45 01 58.87	66 55 16.01	316 36 29 22 14 44	White Horse	136 38 40	6302.8	6892.6	3.92
				Hannah	202 13 08	7830.8	8563.6	4.87
Parker	45 01 50.48	66 54 45.14	70 30 44 234 13 37	North Head	250 29 28	2506.7	2741.2	1.56
				Anley	54 15 19	3894.9	4259.4	2.42
Pendleton	45 01 53.66	66 56 59.07	303 50 37 135 52 47	White Horse	123 54 10	7930.4	8672.4	4.93
				Chamcook	315 47 21	14435.4	15786.1	8.97
Macmaster	45 02 41.11	66 55 35.85	269 29 43 126 52 13	Anley	80 32 01	4329.4	4734.5	2.69
				Chamcook	306 45 48	14835.6	16223.7	9.22
Matthews	45 03 44.35	66 54 17.16	34 22 04 338 47 47	North Head	214 20 28	5271.3	5764.5	3.28
				White Horse	158 49 25	8405.7	9192.2	5.22
Clark's Point, unpainted house, chimney.	45 05 28.41	66 54 18.04	330 01 06 344 31 08	Anley	150 02 29	5137.7	5618.4	3.19
				White Horse	164 32 47	11464.5	12537.2	7.18
Clark's Point, yellow house, chim- ney.	45 05 21.37	66 54 30.74	326 05 51 20 01 56	Anley	146 07 23	5100.5	5577.7	3.17
				North Head	200 00 29	7819.1	8550.8	4.66
Clark's Point, flagstaff	45 05 22.46	66 54 55.38	16 09 51 68 11 09	North Head	196 08 42	7683.5	8402.4	4.77
				Navy	248 05 56	10426.7	11402.3	6.48
Oak Head	44 58 17.94	67 00 52.63	224 46 37 54 06 44	North Head	44 49 40	8066.0	8820.8	5.01
				Perry Pigeon	234 05 04	3821.2	4178.7	2.37
Gardner's Point	44 59 16.28	67 00 09.75	230 23 31 158 51 48	North Head	50 26 04	6155.7	6731.7	3.82
				Chamcook	338 48 37	16313.5	17839.9	10.14
Davidson's Head	45 00 18.71	66 58 54.39	140 59 34 237 09 18	Navy	320 57 10	7071.7	7723.4	4.39
				North Head	57 10 58	3681.8	4026.3	2.29
Perry, north gable of barn	44 57 40.89	67 02 30.84	171 14 10 181 34 15	Chamcook	351 12 39	18372.7	20091.9	11.41
				Navy	1 34 24	10368.9	11339.1	6.44
Perry, south gable of fish-house ...	44 59 15.95	67 03 00.68	187 11 31 171 58 12	Navy	7 12 01	7490.1	8190.9	4.65
				Chamcook	351 57 02	15373.9	16812.5	9.55
Perry, chimney of white house with red door.	44 59 58.62	67 03 54.70	254 49 00 199 07 05	North Head	74 54 13	10016.8	10954.0	6.22
				Navy	19 08 14	6471.2	7076.7	4.02
Perry, south chimney of yellow house with dormer windows.	45 00 05.46	67 04 00.66	256 09 57 200 51 42	North Head	76 15 14	10090.2	11034.3	6.27
				Navy	20 52 55	6317.6	6908.7	3.93
Perry, southeast gable of yellow house.	45 00 47.34	67 04 31.25	212 19 26 263 53 11	Navy	32 21 00	5456.0	5966.7	3.39
				North Head	83 58 50	10527.0	11512.1	6.54

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Passamaquoddy Bay and St. Croix River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	Metres.	Yards.	Miles.
Perry, chimney of one-story white house on Point.	45 01 43.76	67 04 52.66	273 14 30 181 36 21	North Head..... Chamcook.....	93 20 24 1 36 31	10954.0 10664.5	11979.0 11662.3	6.81 6.63
Robbinston, chimney of two-story yellow house.	45 03 25.76	67 06 52.93	145 15 26 272 37 53	Shortland..... Navy.....	325 14 03 92 41 08	4498.8 6025.2	4919.7 6589.0	2.80 3.74
Robbinston, white spire.....	45 05 02.87	67 06 21.15	318 03 08 102 06 46	Hannah..... Shortland.....	138 09 23 282 05 01	17368.6 3332.8	18993.8 3644.7	10.79 2.07
Beacon on west side of St. Andrew's	45 04 15.06	67 03 43.75	108 00 15 299 18 23	Shortland..... North Head.....	287 56 38 119 23 28	7045.1 10811.0	7704.3 11822.6	4.38 6.72
Navy Island Beacon.....	45 03 27.09	67 01 45.73	299 08 17 65 26 19	North Head..... Navy.....	119 11 58 245 25 56	7834.4 772.4	8567.5 844.6	4.87 0.48
Beacon No. 1.....	45 03 44.35	67 00 26.27	310 25 40 70 42 32	North Head..... Navy.....	130 28 25 250 41 13	6704.8 2585.4	7332.1 2827.3	4.17 1.61
Chimney of house on bluff.....	45 05 15.16	67 02 37.48	333 14 38 311 51 58	Hannah..... North Head.....	153 18 15 131 56 16	14899.0 10713.1	16293.1 11715.5	9.26 6.66
West end of barn on Minister Island.	45 06 14.87	67 02 12.22	4 33 07 337 53 15	Perry Pigeon..... Hannah.....	184 32 23 157 56 34	17016.3 16350.1	18608.5 17880.0	10.57 10.16
Block House.....	45 04 36.96	67 04 32.10	299 38 25 104 51 06	North Head..... Shortland.....	119 44 04 281 51 03	12067.8 5842.8	13196.9 6389.5	7.50 3.63
St. Andrew's, short white spire....	45 04 44.84	67 03 05.62	158 05 22 0 43 51	Chamcook..... Perry Pigeon.....	338 04 16 180 43 45	5466.6 14184.4	5978.1 15511.6	3.40 8.81
St. Andrew's, tall white spire.....	45 04 35.84	67 02 52.69	156 32 05 1 54 52	Chamcook..... Perry Pigeon.....	336 30 50 181 54 37	5831.4 13913.2	6377.0 15215.1	3.62 8.65
St. Andrew's, flagstaff.....	45 04 49.15	67 02 50.81	345 48 13 330 44 58	Navy..... Hannah.....	165 48 36 150 48 44	2943.3 14328.2	3218.7 15666.9	1.83 8.90
St. Andrew's, light-house.....	45 04 04.74	67 02 28.89	329 38 11 155 45 01	Hannah..... Chamcook.....	149 41 42 335 43 29	12900.6 6019.9	14107.7 7507.4	8.02 4.30
New Brunswick, chimney at east end of white house.	45 08 54.80	67 07 19.33	17 05 39 307 01 39	Shortland..... Chamcook.....	197 04 35 157 03 33	6758.5 4389.3	7380.9 4800.0	4.20 2.73
<i>Gouldsborough Bay, Narraguagus Bay, Pleasant Bay, Chandler's Bay, Englishman's Bay, and Machias Bay.</i>								
MOUNT DESERT.....	44 21 03.86	68 13 15.48						
HOWARD.....	44 37 45.30	67 23 22.85	65 14 10	Mount Desert.....	244 39 12	72982.2	79811.1	45.35
Pigeon.....	44 27 17.54	67 53 01.92	243 33 56 66 52 24	Howard..... Mount Desert.....	63 54 44 246 38 15	43788.9 23222.7	47886.2 31957.1	27.21 18.16
Burke.....	44 35 54.65	67 58 07.95	337 01 28 265 32 52	Pigeon..... Howard.....	157 05 02 85 57 17	17331.5 46054.4	18953.2 50407.4	10.77 28.64
Mitten.....	44 43 19.33	67 39 45.38	295 22 51 30 41 44	Howard..... Pigeon.....	115 34 22 210 32 25	23968.3 34494.0	26211.0 37721.6	14.89 21.43
Moose-a-bee.....	44 30 08.74	67 30 56.45	215 20 22 154 30 32	Howard..... Mitten.....	35 25 40 334 24 21	17383.7 27044.4	18900.9 29574.9	10.74 16.81
White.....	44 32 49.23	67 44 26.50	107 36 22 48 05 16	Burke..... Pigeon.....	287 26 45 227 59 15	19004.4 15310.5	20782.6 16743.0	11.80 9.51
Tucker.....	44 31 08.01	68 10 39.90	10 28 09 226 49 21	Mount Desert..... Pigeon.....	190 26 20 107 01 42	18960.8 24433.1	20734.9 26719.2	11.78 15.18
Schoodic.....	44 21 01.67	68 02 50.49	90 20 26 151 01 43	Mount Desert..... Tucker.....	270 13 09 330 56 14	13840.7 21399.9	15135.8 23462.3	8.60 13.30
Hovey.....	44 29 18.32	68 01 49.89	5 00 11 44 53 10	Schoodic..... Mount Desert.....	184 59 29 224 45 10	15286.9 21514.1	16826.6 23527.2	9.56 13.17
Ash.....	44 24 37.02	68 05 33.56	331 28 46 150 44 00	Schoodic..... Tucker.....	151 30 40 330 40 25	7563.2 13837.1	8270.9 15131.9	4.70 8.60
Baker's Island Light.....	44 14 27.39	68 11 36.34	223 42 59 169 49 43	Schoodic..... Mount Desert.....	43 49 06 349 48 34	16850.5 12432.0	18427.2 13595.3	10.47 7.72
Petit Manan Light, chimney.....	44 22 02.17	67 51 30.87	82 59 39 134 34 35	Schoodic..... Hovey.....	262 51 44 314 27 22	15163.9 19198.9	16582.8 20995.3	9.42 11.93
Petit Manan, old light-tower.....	44 22 02.26	67 51 30.10	168 13 05 148 55 18	Pigeon..... Tuck.....	348 12 01 328 45 38	9940.3 35335.5	10870.4 38641.8	6.18 21.96
Beacon.....	44 16 46.86	68 13 02.88	239 50 48 177 59 10	Schoodic..... Mount Desert.....	59 57 56 357 59 01	15684.0 7936.8	17151.5 8679.4	9.75 4.93

REPORT OF THE SUPERINTENDENT OF

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Gouldsborough Bay, Narraguagus Bay, Pleasant Bay, Chandler's Bay, &c.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Distance.
	° ' "	° ' "	° ' "		° ' "	Metres.	Yards.	Miles.
Square House, south chimney.....	44 28 12.82	68 05 31.79	198 29 34 37 48 52	Tucker	308 25 58	8692.7	9506.1	5.40
				Mount Desert.....	217 43 28	16748.2	18315.3	10.40
Light-keeper's House, chimney....	44 21 40.34	68 04 53.74	84 14 22 293 16 12	Mount Desert.....	264 08 32	11122.9	12163.6	6.91
				Schoodic	113 17 40	3019.3	3301.8	1.87
Burnt	44 23 57.63	68 11 13.53	295 56 54 260 47 06	Schoodic	116 02 46	12389.0	13548.2	7.70
				Ash	80 51 04	7619.5	8332.5	4.73
Long	44 24 04.95	68 09 38.39	174 03 44 302 01 34	Tucker	354 03 01	13127.6	14355.9	8.16
				Schoodic	122 06 20	10654.8	11651.7	6.62
Jordan	44 24 56.08	68 07 32.83	319 10 00 160 13 11	Schoodic	139 13 18	9560.1	10454.6	5.94
				Tucker	340 11 00	12201.7	13343.4	7.58
Wheeler	44 23 11.26	68 10 30.42	42 54 38 248 01 00	Mount Desert.....	222 52 42	5367.0	5869.1	3.34
				Ash	68 04 37	7081.4	7744.0	4.40
Grindstone	44 22 50.59	68 05 21.59	175 24 02 155 24 13	Ash	355 23 54	3295.5	3603.8	2.05
				Tucker	335 20 30	16888.1	18465.3	10.49
Church at Winter Harbor	44 23 30.00	68 05 04.75	67 25 04 327 05 53	Mount Desert.....	247 19 20	11769.6	12870.9	7.31
				Schoodic	147 07 27	5473.6	5985.7	3.40
Egg	44 21 13.43	68 07 56.70	273 02 32 87 38 31	Schoodic	93 06 06	6790.3	7425.6	4.22
				Mount Desert.....	267 34 48	7064.7	7725.7	4.39
Church at Bar Harbor	44 23 13.35	68 12 02.22	288 20 58 253 14 52	Schoodic	108 27 24	12872.7	14077.2	8.00
				Ash	73 19 24	8979.3	9819.5	5.58
Young	44 18 35.99	68 11 04.73	147 37 32 247 37 47	Mount Desert.....	327 36 01	5405.9	5911.7	3.36
				Schoodic	67 43 32	11834.8	12942.1	7.35
Chimney of small white house with dark roof.	44 25 48.87	68 06 01.13	148 00 15 47 34 49	Tucker	327 57 00	11617.6	12704.6	7.22
				Mount Desert.....	227 29 45	13029.4	14342.6	8.09
St. Bernard	44 24 10.31	68 05 29.63	328 48 17 173 56 55	Schoodic	148 50 08	6804.7	7441.4	4.23
				Ash	353 56 52	828.9	906.4	0.51
Mosquito Harbor Light.....	44 21 40.07	68 04 55.57	84 17 05 293 09 29	Mount Desert.....	264 11 15	11125.6	12166.5	6.91
				Schoodic	113 10 56	3012.9	3294.8	1.87
Newport	44 21 01.69	68 11 18.29	182 35 38 91 30 28	Tucker	2 36 05	18731.4	20484.1	11.64
				Mount Desert.....	271 29 06	2586.0	2838.9	1.61
Twice.....	44 28 03.82	68 11 00.53	12 59 02 320 11 17	Mount Desert.....	192 57 28	13300.6	14545.2	8.27
				Schoodic	140 17 00	16949.6	18535.6	10.53
Chimney of house on Iron-bound island.	44 23 28.53	68 07 55.57	236 02 40 57 47 46	Ash	56 04 19	3788.1	4142.6	2.35
				Mount Desert.....	237 44 02	8372.9	9156.4	5.21
Stave	44 26 16.36	68 08 04.86	312 29 11 324 21 16	Ash	132 30 57	4538.6	4963.3	2.82
				Schoodic	144 24 56	11946.6	13064.4	7.42
Culf	44 27 41.64	68 08 45.84	158 25 30 323 14 48	Tucker	338 24 10	6849.6	7490.5	4.25
				Ash	143 17 03	7109.4	7774.7	4.42
Sullivan Church, No. 1.....	44 30 37.22	68 09 34.57	333 15 21 334 22 15	Schoodic	153 20 03	19885.0	21745.7	12.35
				Ash	154 25 04	12327.0	13480.3	7.66
Sullivan Church, No. 2.....	44 29 24.40	68 09 46.85	329 16 10 327 42 24	Schoodic	149 21 01	18043.7	19731.9	11.21
				Ash	147 45 21	10488.8	11470.2	6.52
Wallace	44 34 01.85	67 51 47.32	7 31 40 194 25 37	Pigeon	187 30 47	12587.3	13765.1	7.82
				East Base	14 27 10	11685.1	12778.4	7.26
Bee	44 23 26.18	67 57 42.63	56 49 47 287 27 17	Schoodic	236 46 11	8145.2	8907.4	5.06
				Petit Manan Light	107 31 37	8627.9	9435.2	5.36
Nash's Island Light, chimney.....	44 27 50.54	67 44 29.88	139 54 50 84 54 28	Wallace	319 49 44	14988.5	16391.0	9.31
				Pigeon	264 48 29	11364.1	12427.4	7.06
Cromer	44 26 32.05	68 00 54.88	14 05 47 262 18 27	Schoodic	194 04 26	10512.6	11496.2	6.53
				Pigeon	82 23 58	10550.3	11537.5	6.56
Newman	44 25 13.17	67 58 18.49	241 14 00 37 49 21	Pigeon	61 17 42	7983.4	8730.4	4.96
				Schoodic	217 46 11	9822.8	10742.0	6.11
Eagle Hill.....	44 27 32.38	67 55 24.36	333 06 02 278 16 10	Petit Manan Light	153 08 45	11426.2	12495.3	7.10
				Pigeon	98 17 47	3181.4	3479.1	1.98
Hathaway.....	44 22 30.97	68 01 22.14	35 22 49 220 21 18	Schoodic	215 21 47	3380.3	3696.6	2.10
				Eagle Hill	40 25 28	12214.5	13357.3	7.59
Hatch	44 24 30.57	68 00 36.22	24 45 39 173 43 13	Schoodic	204 44 05	7099.2	7763.5	4.41
				Cromer	353 43 00	3771.9	4124.9	2.35
Pearl	44 23 36.60	67 58 55.77	154 03 57 195 27 45	Cromer	334 02 34	6021.7	6585.2	3.74
				Newman	15 28 11	3092.5	3361.8	1.92
Hale	44 19 51.74	68 01 33.97	184 00 08 141 51 48	Cromer	4 00 35	19385.5	13544.4	7.70
				Schoodic	321 50 55	2744.0	3000.8	1.70

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Gouldsborough Bay, Narraguagus Bay, Pleasant Bay, Chandler's Bay, &c.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	Metres.	Yards.	Miles.
West chimney of house at head of Gouldsborough Bay.	44 27 56.97	67 59 12.53	40 49 22 278 32 17	Cromer	220 48 10	3462.3	3764.2	2.15
				Eagle Hill	98 34 57	5100.2	5577.4	3.17
Gouldsborough, east chimney of two-story white house.	44 28 52.13	68 01 58.97	341 51 11 324 10 42	Cromer	161 51 56	4549.6	4975.3	2.83
				Newman	144 13 16	8332.3	9111.9	5.18
Chimney of house, frame of build- ing to the west.	44 24 03.77	67 58 14.34	177 33 29 328 49 44	Newman	357 32 26	2143.8	2344.4	1.33
				Bee	148 50 06	1355.8	1482.6	0.84
Steuben, white spire.....	44 30 36.50	67 57 23.60	143 59 00 174 18 42	Tunk	323 53 27	17772.9	19435.9	11.04
				Burke	354 18 11	9868.5	10791.9	6.13
Dyer	44 24 41.86	67 55 40.67	119 06 34 195 28 46	Cromer	296 02 54	7336.5	8023.0	4.56
				Newman	285 26 56	3622.8	3961.8	2.25
West gable-end of barn, east side of Dyer's Bay.	44 26 00.33	67 54 14.75	214 02 24 74 54 58	Pigeon	34 03 15	2875.7	3144.7	1.79
				Newman	254 52 07	5583.9	6106.4	3.47
Chimney of unpainted house, east side of Dyer's Bay.	44 25 12.49	67 54 20.97	105 46 53 204 21 22	Cromer	285 42 17	9050.9	9897.8	5.62
				Pigeon	24 22 17	4236.4	4642.8	2.63
Chimney of house, east side of Dyer's Bay.	44 25 17.75	67 54 09.34	194 22 55 201 57 23	Cromer	284 18 11	9257.0	10123.1	5.75
				Pigeon	21 58 10	3385.8	3688.7	2.48
Petit	44 23 42.61	67 53 39.51	118 32 43 187 08 22	Cromer	268 27 38	10958.5	11983.9	6.81
				Pigeon	7 08 48	6684.9	7310.5	4.16
North chimney of house, west side of Dyer's Bay.	44 25 15.66	67 55 30.08	51 14 13 221 02 37	Schoodic	231 09 05	12502.3	13678.7	7.77
				Pigeon	41 04 21	4988.0	5454.7	3.10
West chimney of white house on Rogers's Point.	44 28 20.28	67 57 58.34	4 11 43 49 17 35	Newman	184 11 30	5790.3	6352.1	3.60
				Cromer	229 15 32	5120.0	5599.1	3.18
Hemlock	44 26 46.42	67 58 36.21	137 37 15 352 14 32	Hovey	317 34 59	6448.3	6942.3	3.94
				Newman	172 14 44	2904.4	3176.1	1.81
Spoon	44 26 45.63	67 57 05.85	126 55 24 29 23 19	Hovey	306 52 05	7849.5	8584.0	4.88
				Newman	209 22 28	3274.6	3581.0	2.04
Cherryfield spire.	44 36 01.44	67 55 07.71	107 56 09 87 00 12	Tunk	287 49 00	14132.0	15454.4	8.78
				Burke	266 58 06	3680.1	4022.5	2.47
Mill River Church, with square steeple.	44 35 51.27	67 50 21.23	12 37 43 103 19 48	Pigeon	192 35 50	16248.3	17768.7	10.10
				Tunk	223 09 18	20305.0	22365.0	12.62
Mitchell	44 33 58.76	67 46 37.26	161 02 54 34 23 13	East Base	341 00 49	12066.4	13195.4	7.50
				Pigeon	214 24 43	15017.3	16422.4	9.33
Clump	44 34 13.42	67 48 11.42	170 26 38 26 34 58	East Base	350 25 39	11113.1	12152.9	6.91
				Pigeon	206 31 34	14350.1	15692.8	8.92
Ripley	44 31 33.22	67 47 34.28	170 29 42 42 33 40	East Base	350 28 17	16135.3	17634.1	10.02
				Pigeon	222 29 50	10708.9	11710.9	6.65
Fort	44 32 33.47	67 50 21.30	121 08 21 20 00 38	Burke	301 02 54	12023.1	13148.1	7.47
				Pigeon	199 58 45	10376.7	11347.6	6.45
Foster	44 31 36.20	67 49 39.59	121 16 23 29 15 42	Tunk	301 05 24	24190.5	26454.0	15.03
				Pigeon	209 13 21	9150.6	10006.9	5.69
Log	44 30 03.93	67 48 04.54	52 01 06 223 18 55	Pigeon	231 57 38	8340.3	9120.7	5.18
				White	43 21 28	7014.1	7670.4	4.36
Millbridge Church, No. 1, tall white spire.	44 32 19.54	67 52 38.24	123 48 18 132 25 17	Tunk	303 39 25	20144.6	22020.5	12.52
				Burke	312 21 26	9849.3	10770.9	6.12
Millbridge Church, No. 2.....	44 31 50.68	67 52 35.11	125 44 50 194 36 10	Tunk	305 35 55	20709.7	22647.5	12.87
				Wallace	14 36 44	4183.6	4575.0	2.60
Flint	44 28 37.87	67 46 49.60	73 16 06 295 18 26	Pigeon	253 11 45	8594.5	9368.7	5.34
				Nash's Island Light	115 20 04	3415.0	3735.2	2.12
Trafton	44 29 21.00	67 49 14.73	52 49 19 224 41 34	Pigeon	232 46 40	6303.2	6893.0	3.92
				White	44 44 56	9044.7	9891.0	5.62
Turner	44 30 09.60	67 51 24.95	21 59 04 187 27 15	Pigeon	201 57 56	5736.7	6262.5	3.56
				East Base	7 28 32	18641.5	20385.7	11.58
Bois Bubert	44 26 25.76	67 51 53.85	136 42 46 255 01 47	Pigeon	316 41 58	2195.3	2400.7	1.36
				Nash's Island Light	75 06 58	10157.6	11108.0	6.31
North chimney of white house on north end of Pond Island.	44 27 49.41	67 49 58.06	76 24 37 133 58 26	Pigeon	256 22 28	4181.7	4573.0	2.60
				Tunk	313 47 41	28463.8	30799.1	17.59
Jordan's Delight.....	44 26 34.31	67 49 06.82	208 07 29 104 24 28	White	28 10 45	13123.7	14351.6	8.16
				Pigeon	284 22 03	5365.7	5867.7	3.34
Chimney of two-story, salmon-col- ored house.	44 28 50.80	67 56 00.30	396 07 19 341 49 45	Pigeon	126 09 54	4881.2	5337.9	3.03
				Eagle Hill	161 50 10	2547.4	2785.8	1.58
Chimney of two-story house, with ends painted red.	44 28 23.42	67 55 14.50	304 44 55 7 52 42	Pigeon	124 46 58	3566.4	3900.1	2.22
				Eagle Hill	187 52 35	1390.1	1738.9	0.99

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Gouldsborough Bay, Narraguagus Bay, Pleasant Bay, Chandler's Bay, &c.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	Metres.	Yards.	Miles.
Chimney of house at head of Dyer's bay.	44 29 26.77	67 54 24.44	335 25 36 20 33 50	Pigeon	155 26 34	4385.8	4796.1	2.73
				Eagle Hill	200 33 08	3770.6	4123.5	2.35
Pinkham	44 28 31.77	67 54 00.70	330 26 54 45 15 13	Pigeon	150 27 35	2633.9	2860.4	1.64
				Eagle Hill	225 14 15	2603.6	2847.2	1.62
White chimney of house at head of Pigeon Hill bay.	44 29 23.02	67 53 17.97	341 13 29 354 46 36	Bois Bubert	161 14 28	5778.2	6318.9	3.59
				Pigeon	174 46 47	3889.3	4253.3	2.42
Chimney of two-story house, east side of bay.	44 27 57.79	67 51 53.20	0 17 06 50 43 41	Bois Bubert	180 17 06	2840.4	3106.1	1.77
				Pigeon	230 42 53	1962.6	2146.2	1.22
Harrington, tall white spire with turrets.	44 37 11.69	67 48 05.50	95 32 52 79 54 44	Tank	275 20 46	29856.3	32495.0	14.20
				Burke	239 47 41	13453.8	14756.5	8.38
Chimney of white house, Cape Split Harbor.	41 32 01.26	67 42 07.37	58 51 52 115 44 39	Pigeon	238 44 13	16904.8	18486.5	10.50
				White	295 43 01	3409.4	3728.4	2.12
Cape Split	44 29 53.67	67 44 13.14	176 52 52 268 54 33	White	356 52 43	5425.5	5933.2	3.37
				Moose-a-bee	88 33 51	17005.1	19252.4	10.94
Chimney of house, west side of bay.	44 26 28.49	67 53 05.05	182 36 21 273 03 24	Pigeon	2 36 23	1515.1	1656.9	0.94
				Bois Bubert	93 04 14	1576.7	1724.2	0.98
Chimney of dark brown house on east side of bay.	44 27 10.18	67 51 51.86	1 49 52 98 20 17	Bois Bubert	181 49 51	1371.7	1500.1	0.85
				Pigeon	278 19 28	1565.9	1712.4	0.97
Chimney of red house, west side of Dyer's bay.	44 26 24.71	67 55 43.46	191 26 02 245 27 04	Eagle Hill	11 26 15	2130.5	2329.8	1.33
				Pigeon	65 28 57	3925.5	4292.8	2.44
Pond Island Light	44 27 20.49	67 49 32.30	166 28 40 213 37 25	Wallace	346 27 05	12741.2	13933.3	7.92
				White	33 40 59	12188.5	13329.0	7.57
Rye-field	44 36 44.16	67 36 04.98	158 19 28 330 48 44	Mitten	338 16 53	13127.1	14355.4	8.16
				Moose-a-bee	150 52 20	13976.0	15283.8	8.68
Kelly	44 33 40.31	67 37 48.01	79 52 20 305 39 48	White	259 47 40	8934.6	9770.6	5.55
				Moose-a-bee	125 44 37	11190.2	12337.2	6.95
Crumple	44 26 33.04	67 35 34.55	222 41 36 194 42 15	Moose-a-bee	42 44 50	9060.8	9908.6	5.63
				White	314 36 02	16519.3	18065.0	10.26
Beals	44 30 28.64	67 36 47.42	113 13 00 274 29 54	White	293 07 38	11025.6	12057.2	6.85
				Moose-a-bee	94 34 00	7777.2	8504.9	4.83
Indian Hill	44 44 18.23	67 26 49.60	41 09 54 83 59 50	Rye-field	221 03 23	18601.3	20341.7	11.55
				Mitten	263 50 44	17164.2	18770.3	10.66
Libby Island Light	44 34 04.68	67 21 41.79	161 54 04 104 31 53	Howard	341 52 53	7163.3	7833.6	4.45
				Rye-field	284 24 47	19663.0	21502.9	12.21
Davis	44 39 03.09	67 12 52.69	80 15 06 117 54 38	Howard	260 07 43	14091.7	15410.3	8.76
				Indian Hill	297 44 49	20855.8	22785.4	12.95
Dwellely	44 43 40.02	67 24 03.22	355 20 42 107 52 30	Howard	175 21 11	10984.8	12012.6	6.83
				Indian Hill	287 50 33	3845.7	4205.5	2.39
Wass	44 35 36.78	67 45 04.32	71 47 51 359 49 55	Wallace	251 43 08	9360.3	10236.1	5.82
				White	170 50 22	5238.5	5738.7	3.25
Look	44 35 27.94	67 43 45.18	10 32 47 98 53 32	White	190 32 18	4962.9	5449.2	3.10
				Wass	278 52 37	1766.5	1931.8	1.10
Moose	44 33 20.20	67 38 57.12	247 50 59 331 35 04	Kelly	67 51 48	1646.9	1801.0	1.02
				Beals	151 36 35	6019.7	6583.0	3.74
Joe Look's House, chimney	44 34 17.57	67 44 39.23	167 14 42 354 07 20	Wass	347 14 24	2506.6	2741.1	1.56
				White	174 07 29	2741.3	2997.8	1.70
Charles Wooster's House, chimney.	44 34 43.05	67 45 19.29	191 15 51 236 16 18	Wass	11 16 02	1690.8	1849.0	1.05
				Look	56 17 24	2495.7	2729.2	1.55
Easternmost of three trees on hill.	44 37 01.06	67 44 55.64	331 36 10 4 12 35	Look	151 36 59	3267.3	3573.0	2.03
				Wass	184 12 29	2608.5	2852.6	1.62
Church at Addison Point	44 37 10.98	67 44 13.69	348 49 02 21 00 32	Look	168 49 22	3242.4	3545.8	2.02
				Wass	200 59 57	3115.0	3406.5	1.94
South chimney of white house, with long L.	44 36 17.03	67 43 55.03	351 50 35 50 53 23	Look	171 50 42	1530.8	1674.1	0.95
				Wass	230 52 34	1969.4	2153.7	1.22
Small brown house, chimney	44 35 51.29	67 43 54.42	344 12 45 73 48 03	Look	164 12 52	749.1	819.2	0.46
				Wass	253 47 14	1605.2	1755.4	1.00
Moose-a-bee Light, or Head Har- bor Light.	44 28 26.73	67 31 34.86	115 29 50 231 24 16	White	295 20 49	18269.3	20034.9	11.72
				Libby Island Light	51 31 12	16742.6	18303.1	10.40
Hardwood	44 30 46.81	67 39 16.98	118 57 45 276 01 03	White	298 54 08	7808.3	8538.9	4.85
				Moose-a-bee	96 06 54	11118.2	12158.5	6.91
Rake	44 28 42.25	67 34 50.41	242 40 26 120 58 52	Moose-a-bee	62 43 10	5818.2	6362.6	3.61
				White	300 52 08	14831.0	16218.8	9.22

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	° ' "	° ' "	° ' "		° ' "	Metres.	Yards.	Miles.
Brown	44 27 46.18	67 36 41.41	239 58 38 132 21 35	Moose-a-bee White	60 02 40 312 16 09	8801.9 13292.5	9655.5 15192.4	5.47 8.63
Stevens	44 29 23.47	67 39 41.96	313 51 40 135 19 44	Crumple White	133 54 31 315 16 24	7587.5 8933.6	8297.5 9769.5	4.71 5.55
Outer Sand	44 27 43.87	67 40 03.39	249 38 42 148 21 44	Moose-a-bee White	69 45 05 329 18 39	12886.8 11071.6	14092.5 12107.6	8.01 6.88
Hall's Hill, flagstaff	44 35 06.78	67 38 48.79	60 21 40 230 13 34	White Ryefield	240 17 43 50 15 29	8576.5 4699.2	9379.0 5138.9	5.33 2.92
Indian River Church, No. 1	44 34 21.85	67 38 13.99	70 51 27 212 55 28	White Ryefield	250 47 06 32 56 59	8703.4 5233.2	9517.8 5722.9	5.41 3.25
Indian River Church, No. 2	44 34 22.83	67 38 16.43	70 33 08 213 35 53	White Ryefield	250 28 48 34 37 25	8662.5 5237.5	9473.0 5727.6	5.38 3.25
Rogue	44 35 11.03	67 30 23.72	4 25 21 195 34 55	Moose-a-bee Indian Hill	184 24 58 15 37 25	9358.3 17334.8	10234.0 19175.5	5.81 10.90
Woodard	44 33 33.42	67 34 19.45	84 14 27 324 37 25	White Moose-a-bee	264 07 31 144 39 47	13466.3 7746.7	14726.3 8471.5	8.37 4.81
Great Spruce	44 33 30.73	67 29 23.88	124 03 03 18 08 49	Ryefield Moose-a-bee	303 58 21 198 07 44	10672.7 6561.0	11671.4 7174.9	6.63 4.08
Mark	44 31 50.14	67 31 48.89	339 41 46 225 28 22	Moose-a-bee Howard	159 42 23 45 34 17	7336.8 15645.3	3649.0 17109.2	2.07 9.72
Flat	44 27 36.43	67 42 08.84	162 31 45 207 07 42	White Kelly	342 30 08 27 10 45	10121.4 12622.0	11068.4 13803.1	6.29 7.84
Norton	44 32 06.77	67 36 45.83	97 23 08 351 18 03	White Crumple	277 17 45 171 18 53	10252.6 10419.8	11211.9 11394.8	6.37 6.47
Chandler	44 32 21.50	67 40 25.57	288 00 20 99 09 54	Moose-a-bee White	108 06 59 279 07 05	13218.9 5386.3	14455.7 5890.3	8.21 3.35
Doyle	44 31 47.37	67 38 28.99	286 53 51 103 37 40	Moose-a-bee White	106 59 08 283 33 29	10447.9 8119.6	11425.5 8879.4	6.49 5.04
Head Harbor	44 30 39.01	67 33 05.95	23 24 20 160 42 05	Crumple Ryefield	203 22 36 340 39 59	8271.5 10942.2	9045.4 11966.1	5.14 6.80
Plummer	44 29 08.84	67 41 30.69	262 25 23 301 25 16	Moose-a-bee Crumple	82 32 48 121 27 26	14133.9 9223.9	15456.4 10087.0	8.78 5.73
Church at Jonesport	44 32 00.44	67 35 26.81	32 09 02 236 15 03	Beals Howard	212 08 05 56 23 31	3346.5 19193.0	3659.6 20988.9	2.08 11.92
Sawyer	44 37 32.48	67 32 36.21	138 36 05 350 51 30	Mitten Moose-a-bee	318 31 03 170 52 40	14280.9 13771.6	15617.2 15169.6	8.87 8.62
Shoppe	44 37 18.76	67 28 58.21	11 07 37 192 19 33	Moose-a-bee Indian Hill	191 06 14 12 21 03	13526.8 13252.9	14792.5 14493.0	8.41 8.24
The Brothers	44 33 23.80	67 25 49.15	135 00 33 201 46 35	Mitten Howard	314 50 46 21 48 18	26027.7 8691.8	28463.1 9505.1	16.18 5.40
Starboard	44 36 13.30	67 23 54.53	39 38 57 193 49 00	Moose-a-bee Howard	219 34 01 13 49 22	14605.1 2924.4	15971.7 3198.0	9.08 1.82
Chimney of house on Libby Island, (northernmost island.)	44 34 56.72	67 20 56.13	56 12 14 99 29 05	Moose-a-bee Ryefield	236 05 13 279 18 27	15955.5 20315.2	17448.4 22216.1	9.92 12.62
Rogers	44 35 55.79	67 33 12.25	255 21 49 111 25 04	Howard Ryefield	75 28 43 291 23 03	13427.1 4091.8	14683.5 4474.7	8.34 2.54
Cross	44 36 16.27	67 18 09.07	142 25 34 111 41 56	Indian Hill Howard	322 19 28 291 38 16	18781.2 7442.2	20538.5 8138.6	11.67 4.63
Machias, white spire	44 42 56.39	67 27 08.12	251 39 51 189 10 28	Dwelley Indian Hill	71 42 01 9 10 41	4285.8 2558.0	4686.8 2797.3	2.66 1.59
School-house at Machias Point	44 41 49.48	67 23 29.18	136 10 28 290 03 36	Indian Hill Davis	316 08 07 110 11 04	6357.1 14929.9	6962.9 16326.9	3.96 9.28
Buck's	44 39 18.89	67 22 31.75	272 07 57 148 27 35	Davis Indian Hill	92 14 44 328 24 34	12767.4 10843.8	13962.0 11858.5	7.93 6.74
Lowell	44 42 27.28	67 20 00.50	303 44 23 27 08 07	Davis Howard	133 49 24 207 05 45	11334.2 9777.8	12394.7 10692.7	7.04 6.08
Sprague	44 39 28.07	67 19 12.42	140 33 48 131 42 40	Dwelley Indian Hill	320 30 23 311 37 18	10072.6 13471.8	11015.1 14732.4	6.26 8.37
Thornton	44 37 34.14	67 16 22.49	138 06 12 132 09 03	Dwelley Indian Hill	318 00 48 312 01 42	15181.8 18606.8	16602.4 20347.7	9.43 11.56
Machias Town-hall, cupola	44 43 01.41	67 27 01.64	186 22 34 253 05 56	Indian Hill Dwelley	6 22 42 73 08 02	2385.8 4103.0	2600.0 4486.9	1.48 2.55

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	° ' "	° ' "	° ' "		° ' "	Meters.	Yards.	Miles.
Captain Burnham's House, chimney	44 43 15.61	67 25 21.08	162 00 58 256 02 20	Indian Hill..... Dwellely.....	342 60 38 76 03 57	2032.1 3125.6	2252.2 3418.0	1.26 1.94
Old Church opposite Machias Port	44 42 03.36	67 22 45.68	127 49 05 150 14 18	Indian Hill..... Dwellely.....	307 46 13 330 13 24	6792.4 3436.8	7427.9 3758.3	4.22 2.14
Seal Island, east light	44 39 06.35	67 05 45.48	173 59 29 121 22 02	Trescott Rock..... Howard.....	358 59 13 301 09 40	28543.2 27293.8	31214.0 29847.7	17.74 16.96
Little Kennebec	44 38 58.55	67 26 17.30	300 21 49 353 29 10	Howard..... The Brothers.....	120 23 52 176 29 30	4471.2 10351.0	4889.6 11319.5	2.78 6.43
New Barn, north gable	44 36 45.92	67 25 44.97	239 39 30 169 57 07	Howard..... Little Kennebec.....	59 41 10 349 56 44	3629.3 4157.7	3968.9 4546.7	2.25 2.58
Yellow House, east chimney	44 40 48.98	67 27 09.61	341 30 56 318 35 40	Little Kennebec..... Howard.....	161 51 32 138 38 20	3593.6 7536.3	3929.8 8263.4	2.23 4.70
White House, west chimney	44 40 11.62	67 25 30.83	24 41 45 328 00 37	Little Kennebec..... Howard.....	304 41 12 148 02 07	2481.9 5324.2	2714.2 5822.4	1.55 3.31
Bell	44 46 31.68	67 16 41.32	207 02 05 28 35 08	Arcus..... Howard.....	27 05 57 208 30 26	15925.6 18494.5	17415.7 20225.0	9.90 11.49
Dennison	44 38 27.23	67 13 48.49	84 13 00 227 57 05	Howard..... Davis.....	264 06 16 47 57 44	12723.5 1632.2	13914.0 1266.8	7.91 1.03
Old Man	44 37 08.97	67 13 51.13	200 02 50 300 19 01	Davis..... Dennison.....	20 03 31 1 22 55	3749.0 2415.9	4099.7 2641.9	2.33 1.50
Chimney of house with frame of barn to east.	44 40 07.48	67 15 57.04	324 56 01 300 19 01	Dennison..... Davis.....	144 57 10 120 20 49	3780.2 3926.7	4133.9 4305.0	2.35 2.45
Sandy Point	44 40 22.08	67 09 02.89	347 04 39 04 18 18	Seal Island, east light..... Davis.....	167 06 57 244 15 57	19496.7 5620.9	21321.0 6146.9	12.11 3.59
Colville	44 39 36.52	67 12 45.53	8 48 54 76 19 22	Davis..... Howard.....	188 48 49 256 12 00	1045.0 14456.1	1142.8 15808.8	0.65 8.98
Lookout	44 39 23.01	67 11 34.97	70 15 23 241 25 45	Davis..... Sandy Point.....	250 14 28 61 27 32	1822.5 3814.1	1993.0 4171.0	1.13 2.37
Ravine	44 41 18.61	67 08 18.88	55 17 06 209 13 45	Davis..... Trescott Rock.....	235 13 53 20 15 17	7341.2 8303.0	8028.1 9079.9	4.56 5.16
Bog Creek	44 43 05.08	67 06 30.72	186 13 42 48 25 58	Trescott Rock..... Davis.....	6 13 58 228 21 29	4529.7 11250.7	4953.5 12303.5	2.81 6.99
<i>Penobscot Bay and River.</i>								
Isle au Haut	44 04 01.90	68 36 42.51						
Fox Rocks	44 06 26.90	68 52 21.53	282 00 03	Isle au Haut.....	102 10 56	21361.7	23360.5	13.27
North Fox	44 10 51.45	68 49 17.74	306 54 02 26 35 37	Isle au Haut..... Fox Rocks.....	127 02 48 206 33 29	21015.0 9120.2	23081.4 9983.5	13.06 5.67
Deer Isle	44 13 24.20	68 39 42.68	346 34 20 52 28 28	Isle au Haut..... Fox Rocks.....	166 36 30 232 19 44	17839.8 21108.4	19509.1 23083.5	11.08 13.12
Burnt Cove	44 09 18.59	68 40 50.78	71 01 36 190 18 16	Fox Rocks..... Deer Isle.....	250 53 35 10 18 59	16242.3 7704.4	17762.1 8425.3	10.09 4.79
Coombs Hill	44 05 17.38	68 46 51.63	106 19 53 162 31 52	Fox Rocks..... North Fox.....	286 16 03 342 30 10	7644.1 10809.4	8359.4 11829.9	4.75 6.72
Swan's Island	44 09 43.97	68 25 00.12	56 00 34 109 05 37	Isle au Haut..... Deer Isle.....	235 52 25 288 55 18	18850.2 20867.9	20614.0 22820.5	11.71 12.97
Patterson	44 22 17.38	69 02 56.75	298 00 18 334 16 35	Deer Isle..... Fox Rocks.....	118 16 27 154 23 58	34890.9 32544.1	38155.7 35589.3	21.68 20.22
Whitmore's Harbor, church spire	44 11 09.16	68 37 01.00	279 14 36 358 07 33	Swan's Island..... Isle au Haut.....	99 22 59 178 07 47	16245.9 13192.0	17766.1 14427.5	10.09 8.20
Northwest Harbor, church spire	44 13 13.55	68 40 15.97	6 05 07 344 24 37	Burnt Cove..... Isle au Haut.....	186 04 43 164 27 06	7292.3 17673.6	7974.6 19327.3	4.53 10.98
Northwest Harbor, parsonage	44 13 19.47	68 39 56.44	345 55 15 52 30 13	Isle au Haut..... Fox Rocks.....	165 57 31 232 21 34	17739.1 20882.9	19399.0 22836.9	11.02 12.98
North end of Deer Isle, north church spire.	44 16 10.68	68 40 01.16	348 52 49 51 28 39	Isle au Haut..... North Fox.....	168 55 07 231 22 11	22920.2 15799.7	25064.8 17278.1	14.24 9.82
North end of Deer Isle, south church spire.	44 15 50.89	68 40 04.76	53 04 49 43 18 18	North Fox..... Fox Rocks.....	232 58 23 223 09 45	15361.6 23286.5	16798.9 26121.6	9.55 14.84
Brooklin, church spire	44 16 00.69	68 33 47.19	9 58 28 58 58 35	Isle au Haut..... Deer Isle.....	189 56 26 238 54 23	22522.2 9361.8	24629.6 10237.8	14.00 5.82
Kent's Hill	44 08 58.67	68 50 05.53	327 43 16 32 51 11	Coombs Hill..... Fox Rocks.....	147 45 31 212 49 36	8075.9 5574.8	8831.6 6096.4	5.02 3.46

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section 1—Penobscot Bay and River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	D. I. "	D. I. "	D. I. "		D. I. "	Miles.	Yards.	Miles.
Stimpson's Island.....	44 08 09.72	68 49 02.90	54 19 00 258 57 17	Fox Rocks.....	234 16 42	5437.7	5946.5	3.38
				Burnt Cove.....	79 03 00	11140.7	12183.2	6.92
Stinson's Point, flag in tree.....	44 10 19.07	68 42 41.84	367 05 21 96 31 12	Burnt Cove.....	127 06 38	3694.3	3383.8	1.92
				North Fox.....	276 26 36	8850.1	9678.2	5.50
Calderwood's Neck, tree with tuft.....	44 06 39.96	68 49 32.47	305 27 12 182 24 49	Coombs Hill.....	125 29 04	4391.8	4802.8	2.73
				North Fox.....	2 24 50	7758.5	8495.4	4.83
Brimstone Island, flag in tree.....	44 00 44.77	68 45 48.28	140 23 00 202 37 27	Fox Rocks.....	320 18 27	13713.9	14397.1	8.52
				Burnt Cove.....	22 40 54	17182.7	18790.5	10.68
Tree with tuft, near Fox Rocks.....	44 06 26.80	68 51 52.28	90 15 15 231 13 21	Fox Rocks.....	270 14 55	650.5	711.3	0.40
				Deer Isle.....	51 21 45	20599.2	22526.7	12.80
Job Banks's House, chimney.....	44 09 43.24	68 49 09.00	339 34 24 174 43 42	Coombs Hill.....	159 36 00	8754.7	9575.8	5.44
				North Fox.....	354 43 36	2114.2	2312.0	1.31
Babbidge's Island, flag in tree.....	44 08 32.26	68 46 41.67	259 34 35 141 06 25	Burnt Cove.....	79 38 40	7827.0	8668.8	4.93
				North Fox.....	321 04 36	5520.5	6037.0	3.43
Eagle Island Light.....	44 13 02.61	68 45 44.05	324 08 34 316 40 11	Isle au Haut.....	144 14 51	20771.9	22496.8	12.79
				Burnt Cove.....	136 43 35	9495.7	10384.2	5.90
Deer Isle, square-tower church.....	44 11 41.45	68 39 24.90	39 59 37 23 24 09	Coombs Hill.....	219 54 26	15461.3	16908.0	9.61
				Burnt Cove.....	203 23 09	4803.9	5253.4	2.98
Saddleback Light.....	44 00 50.58	68 43 15.24	191 34 11 235 55 36	Burnt Cove.....	11 35 52	16003.8	17501.3	9.94
				Isle au Haut.....	56 00 09	10550.0	11537.2	6.36
Saddleback Island.....	44 00 50.00	68 43 15.65	149 47 49 191 35 18	Coombs Hill.....	329 45 19	9550.0	10443.6	5.93
				Burnt Cove.....	11 36 59	10023.5	10922.8	5.96
Mark Island Light.....	44 08 02.69	68 41 51.79	210 03 54 52 36 20	Burnt Cove.....	30 04 36	2708.4	2959.6	1.68
				Coombs Hill.....	232 32 56	8395.3	9180.8	5.22
Church spire on Isle au Haut.....	44 04 24.66	68 37 42.70	127 45 28 155 16 08	North Fox.....	307 37 24	19524.4	21351.3	12.19
				Burnt Cove.....	335 13 57	9988.7	10923.3	6.21
Jesse Calderwood's House, chim- ney.....	44 06 48.81	68 48 11.72	327 43 50 168 55 12	Coombs Hill.....	147 44 46	3236.6	3648.8	2.07
				North Fox.....	348 54 26	7630.9	8344.9	4.74
Spruce Head.....	44 14 21.33	68 49 06.64	278 03 05 2 10 51	Deer Isle.....	98 00 34	12506.0	13676.2	7.77
				North Fox.....	182 10 43	6482.0	7085.5	4.03
Bradbury's Island, flag in tree.....	44 14 40.71	68 45 21.80	287 41 37 36 31 54	Deer Isle.....	107 45 29	7759.2	8485.3	4.82
				North Fox.....	216 29 09	8802.9	9626.6	5.47
Pickering's Island, flag in tree.....	44 15 43.57	68 44 32.13	304 20 41 35 08 19	Deer Isle.....	124 23 59	7618.9	8331.8	4.73
				North Fox.....	215 05 00	11020.8	12052.0	6.85
Ojier.....	44 11 43.48	69 03 12.12	104 15 52 303 59 21	Ragged Mount.....	284 12 01	7590.9	8301.2	4.72
				Fox Rocks.....	124 06 55	17448.0	19080.6	10.64
Gilkey.....	44 14 23.53	68 55 10.25	80 24 57 65 15 27	Ragged Mount.....	260 15 30	18308.0	20021.7	11.57
				Ojier.....	245 09 51	11780.9	12853.3	7.32
Garey.....	44 15 45.25	69 00 42.67	288 50 58 23 58 42	Gilkey.....	108 54 50	7793.4	8529.6	4.84
				Ojier.....	203 56 58	8165.4	8929.4	5.07
Dyer.....	44 08 40.16	68 54 15.99	328 14 45 173 31 07	Fox Rocks.....	148 16 04	4836.2	5288.7	3.01
				Gilkey.....	353 30 29	10665.2	11663.1	6.63
Pigeon Hill.....	44 08 03.73	68 52 46.94	349 17 32 119 36 50	Fox Rocks.....	169 17 50	3041.2	3325.7	1.89
				Dyer.....	299 35 48	2270.2	2489.2	1.41
Calderwood Rock.....	44 07 33.92	68 50 08.14	55 07 10 104 37 28	Fox Rocks.....	235 05 37	3615.6	3953.9	2.25
				Pigeon Hill.....	284 35 37	3647.7	3989.0	2.27
Mark Island, flag in tree.....	44 10 20.66	68 58 38.16	310 43 16 211 36 12	Fox Rocks.....	130 47 38	11050.3	12084.2	6.87
				Gilkey.....	31 38 37	8892.5	9626.1	5.47
Duck Trap, church spire.....	44 17 26.14	69 00 09.67	310 02 11 332 53 39	North Fox.....	130 09 46	18910.8	20680.3	11.75
				Fox Rocks.....	152 59 05	22846.8	24964.5	14.20
Temperance.....	44 19 04.23	68 58 18.44	341 14 28 334 15 48	Fox Rocks.....	161 18 37	24679.4	26888.7	15.34
				Gilkey.....	154 18 00	9615.5	10515.2	5.98
McIntire, flag in tree.....	44 10 52.00	69 03 29.83	39 31 01 193 54 24	Bear Hill.....	219 29 14	5355.4	5856.5	3.33
				Ojier.....	13 54 36	1636.6	1789.7	1.02
Mount Battie, flag in tree.....	44 13 21.36	69 03 48.78	80 01 10 260 29 01	Ragged Mount.....	239 57 44	6643.5	7265.1	4.13
				Gilkey.....	80 35 03	11665.3	12756.8	7.25
Lasell's Island, flag in tree.....	44 11 42.40	68 57 22.47	210 32 14 90 16 51	Gilkey.....	30 33 46	5773.9	6314.2	3.59
				Ojier.....	270 12 47	7763.6	8490.0	4.82
Griddle's Point Light.....	44 16 52.54	68 56 14.67	342 43 57 70 45 49	Gilkey.....	102 41 42	4815.7	5266.3	2.99
				Garey.....	250 42 42	6254.2	6884.2	3.91
Graves.....	44 10 55.29	69 01 46.67	128 05 29 129 00 46	Ojier.....	308 04 31	2410.8	2636.4	1.50
				Garey.....	9 01 31	9000.6	9908.4	5.63

REPORT OF THE SUPERINTENDENT OF
UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Penobscot Bay and River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	Metres.	Yards.	Miles.
Negro Island Light	44 12 03.86	69 02 36.09	200 12 37 246 25 06	Garey..... Gilkey.....	20 13 54 66 30 17	7281.2 10793.1	7962.5 11803.0	4.52 6.71
Turner's House, chimney	44 10 02.58	68 51 53.21	151 30 39 246 23 21	Gilkey..... North Fox.....	331 28 22 66 25 09	9164.6 3768.4	10022.1 4121.0	5.69 2.34
Blake's Point.....	44 18 34.81	68 47 33.04	312 54 14 230 05 50	Deer Isle..... Blue Hill.....	132 59 38 50 14 32	14069.3 21521.1	15385.8 23534.8	8.74 13.38
Little Deer Isle.....	44 17 10.04	68 42 09.47	60 40 13 39 09 47	Spruce Head..... North Fox.....	240 35 22 219 04 48	10616.5 15060.8	11609.9 16470.1	6.60 9.36
Billings.....	44 18 53.61	68 39 50.92	55 45 40 359 43 13	Spruce Head..... Deer Isle.....	235 39 12 179 43 15	14914.5 10166.5	16310.0 11117.8	9.27 6.32
Little Torry Island.....	44 14 54.75	68 34 42.50	112 53 11 137 10 52	Little Deer Isle..... Billings.....	292 47 59 317 07 17	10755.7 10054.9	11762.1 10995.8	6.68 6.25
Naskeag Point.....	44 14 04.93	68 31 39.04	168 16 54 129 17 30	Blue Hill..... Billings.....	348 14 20 309 11 47	22586.4 14082.7	24699.8 15400.5	14.04 8.75
J. Simpson's Barn, west gable.....	44 13 18.20	68 43 18.68	192 06 05 60 25 51	Little Deer Isle..... North Fox.....	12 06 53 240 21 41	7318.0 9168.5	8002.7 10026.4	4.55 5.70
Barn on Hog Island, south gable	44 17 01.56	68 47 10.65	27 29 46 170 13 08	Spruce Head..... Blake's Point.....	207 28 25 350 12 52	5574.1 2920.3	6095.7 3193.5	3.46 1.81
Pumpkin Island Light	44 18 31.99	68 44 14.43	39 58 32 91 08 57	Spruce Head..... Blake's Point.....	219 55 08 271 06 38	10090.9 4402.3	11035.1 4814.2	6.27 2.74
S. Black's House, chimney.....	44 18 09.90	68 43 35.60	46 10 17 330 15 50	Spruce Head..... Deer Isle.....	226 06 26 150 18 28	10180.7 10152.5	11133.3 11102.4	6.33 6.31
D. Eaton's House, chimney.....	44 13 24.95	68 42 43.83	186 15 17 101 36 46	Little Deer Isle..... Spruce Head.....	6 15 41 281 32 19	6888.8 9482.0	7642.7 10392.4	4.34 5.39
Dead-top Tree.....	44 14 00.76	68 47 13.31	229 26 07 104 56 04	Little Deer Isle..... Spruce Head.....	49 39 43 284 54 49	9019.5 2464.3	9863.5 2694.9	5.60 1.53
Lone Spruce Tree	44 17 35.42	68 48 09.67	11 54 52 203 52 44	Spruce Head..... Blake's Point.....	191 54 12 23 53 10	6121.6 2004.5	6694.3 2192.0	3.80 1.25
Backman's Hill.....	44 21 11.50	68 46 58.45	326 30 39 319 18 07	Deer Isle..... Little Deer Isle.....	146 35 39 139 21 29	17285.4 9824.6	18902.8 10743.9	10.74 6.10
Billings' Mount, flag in tree	44 19 05.41	68 42 19.82	307 17 55 276 17 11	Little Torry Island..... Billings.....	127 23 14 96 18 55	12753.0 3319.6	13946.3 3630.2	7.92 2.06
Carter's House, north chimney.....	44 17 04.38	68 36 52.45	324 13 21 91 27 18	Little Torry Island..... Little Deer Isle.....	144 14 52 271 23 37	4930.5 7688.3	5391.8 8437.3	3.06 4.37
F. Johnson's House, chimney.....	44 15 26.86	68 37 56.52	158 20 03 282 56 52	Billings..... Little Torry Island.....	338 18 43 102 59 07	6866.4 4416.2	7508.9 4829.4	4.27 2.74
Bass Harbor Head Light.....	44 13 18.03	68 19 54.22	52 58 38 45 49 14	Isle au Haut..... Swan's Island.....	232 26 56 225 45 41	28225.1 9282.6	30866.1 10151.1	17.54 5.77
Fly Island Light.....	44 14 54.49	68 29 32.39	61 26 50 160 15 36	Naskeag Point..... Blue Hill.....	241 25 22 340 11 43	3199.2 21874.0	3498.6 23920.8	1.99 13.59
Bluff.....	44 13 19.88	68 32 26.78	134 12 24 217 17 50	Little Torry Island..... Naskeag Point.....	314 10 49 37 18 23	4200.3 1748.0	4593.3 1911.5	2.61 1.09
Lone Tree.....	44 13 51.66	68 34 32.85	173 43 31 263 55 12	Little Torry Island..... Naskeag Point.....	353 43 24 83 57 13	1958.9 3878.4	2142.2 4241.3	1.22 2.41
Cape Rosier.....	44 19 13.31	68 49 02.62	0 33 56 88 45 00	Spruce Head..... Temperance.....	180 33 53 268 38 32	9011.3 12318.8	9854.5 13471.4	5.60 7.65
Dickey's Bluff.....	44 21 29.82	68 57 16.10	291 01 52 320 35 11	Cape Rosier..... Spruce Head.....	111 07 37 140 40 53	11714.2 17104.7	12810.3 18705.1	7.29 10.63
Castine.....	44 23 17.28	68 48 35.65	4 32 12 58 52 34	Cape Rosier..... Temperance.....	184 31 53 238 45 47	7553.4 15084.2	8260.2 16495.6	4.69 9.37
Moose Point.....	44 25 43.83	68 56 19.52	9 04 38 293 44 21	Dickey's Bluff..... Castine.....	189 03 58 113 49 46	7939.0 11214.9	8681.8 12364.3	4.93 6.97
Patershal's Hill.....	44 26 50.10	69 00 54.83	333 53 39 17 47 06	Dickey's Bluff..... Patterson.....	153 56 12 197 45 41	11006.1 9665.3	12036.0 10549.3	6.84 5.49
Cape Jellison.....	44 27 07.48	68 50 51.20	60 55 08 39 17 31	Patterson..... Dickey's Bluff.....	240 46 40 219 13 02	18370.2 13458.1	20099.0 14717.4	11.42 8.36
Kedear's Hill.....	44 22 23.13	68 53 14.27	316 24 12 254 48 35	Cape Rosier..... Castine.....	136 27 08 74 51 50	8086.0 6389.6	8842.6 6967.5	5.02 3.97
Mount Ephraim	44 31 26.31	68 56 54.60	25 19 54 1 28 54	Patterson..... Dickey's Bluff.....	205 15 40 181 28 39	18738.6 18415.7	20492.0 20138.8	11.64 11.44
Little Ball.....	44 29 18.14	68 44 19.08	103 24 38 65 05 04	Mount Ephraim..... Cape Jellison.....	283 15 48 245 00 29	17149.4 9558.0	18754.4 10452.3	10.66 5.94

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Penobscot Bay and River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	Metres.	Yards.	Miles.
Webster.....	44 26 37.05	68 46 51.63	214 07 51 20 28 39	Little Ball..... Castine.....	34 09 38 200 27 27	6007.4 6580.8	6589.5 7196.6	3.73 4.09
Perry.....	44 33 32.30	68 43 34.01	7 14 03 100 13 56	Little Ball..... Mount Waldo, (B).....	187 13 31 280 07 04	7997.4 13168.1	8647.3 14400.3	4.91 8.18
Sandy Point.....	44 30 35.69	68 48 36.39	292 48 37 141 03 10	Little Ball..... Mount Waldo, (B).....	112 51 37 320 50 50	6167.2 10093.7	6744.3 10939.7	3.83 6.21
McCloud's.....	44 32 58.79	68 46 53.14	77 55 34 333 26 27	Mount Ephraim..... Little Ball.....	257 48 32 153 28 15	13580.5 7612.9	14851.2 8325.3	8.44 4.73
Bucksport.....	44 34 44.71	68 46 58.26	15 44 47 296 21 44	Sandy Point..... Perry.....	195 43 38 116 24 07	7985.6 5030.5	8732.8 5501.2	4.96 3.13
Cobb's Hill.....	44 38 52.47	68 48 15.78	41 45 40 327 48 48	Mount Waldo, (B)..... Perry.....	221 42 05 147 52 06	10124.2 11672.7	11071.5 12765.0	6.29 7.25
Treat's.....	44 36 26.30	68 51 12.59	220 48 22 299 10 51	Cobb's Hill..... Bucksport.....	40 50 26 119 13 49	5961.3 6425.9	6519.1 7027.2	3.70 3.99
Trevett's.....	44 39 03.30	68 50 51.38	22 45 51 5 30 40	Mount Waldo, (B)..... Treat's.....	202 44 06 185 30 25	8555.7 4868.2	9356.2 5323.7	5.32 3.03
Mark Island 2.....	44 15 29.30	68 51 22.90	304 43 56 125 47 39	Spruce Head..... Temperance.....	124 45 31 305 42 40	3679.1 11352.0	4023.4 12414.2	2.29 7.05
Isleboro', south church.....	44 17 23.03	68 54 09.63	49 00 24 70 56 18	Ojer..... Garey.....	228 54 06 250 51 44	15958.5 9222.7	17451.7 10085.7	9.92 5.73
Isleboro', Baptist church.....	44 19 55.41	68 53 35.25	226 46 00 120 48 09	Castine..... Dickey's Bluff.....	46 49 29 300 45 35	9100.5 5693.3	9952.0 6226.0	5.66 3.54
Decker's House, chimney.....	44 20 42.61	68 52 21.04	159 12 00 162 35 56	Kedear's Hill..... Dickey's Bluff.....	339 11 23 282 32 30	3318.6 6694.4	3629.1 7320.8	2.06 4.16
Sears House, west chimney.....	44 25 54.70	68 52 23.67	340 13 12 313 53 57	Cape Rosier..... Castine.....	160 15 33 131 56 37	13163.6 7693.6	14395.3 8398.9	8.18 4.35
Sandy Point, Congregationalist church, white spire.....	44 30 42.44	68 48 31.34	0 23 47 22 07 28	Castine..... Kedear's Hill.....	180 23 44 202 04 10	13737.2 16631.3	15022.6 18187.5	8.54 10.33
Sandy Point, Universalist church, gray spire.....	44 30 39.36	68 48 32.59	0 16 58 22 09 27	Castine..... Kedear's Hill.....	180 16 56 202 06 10	13643.7 16533.7	14920.3 18080.7	8.48 10.27
Dice's Head Light.....	44 22 56.89	68 48 48.52	60 25 08 76 35 57	Temperance..... Dickey's Bluff.....	240 18 30 256 30 02	14521.2 11553.4	15879.9 12634.4	9.02 7.18
Seal Island, flag in tree.....	44 19 39.26	68 55 17.26	74 56 41 142 22 03	Temperance..... Dickey's Bluff.....	254 54 34 322 20 40	4357.3 4369.4	4546.3 4712.6	2.58 2.68
Head of Tide, church spire.....	44 26 56.89	69 02 59.05	274 21 05 359 39 52	Patershal's Hill..... Patterson.....	94 22 32 179 39 54	2754.5 8626.1	3012.2 9433.3	1.71 5.36
Belfast Monument, (Steel's ledge).....	44 25 08.52	68 58 00.76	51 09 02 244 02 02	Patterson..... Moose Point.....	231 05 35 64 03 13	8414.0 2490.0	9201.3 2723.0	5.23 1.55
Belfast, Methodist church spire.....	44 25 28.54	68 59 59.08	284 55 54 264 25 52	Castine..... Moose Point.....	105 03 52 84 28 32	15653.9 4879.6	17118.7 5336.2	9.73 3.03
Conner's Steam Mill, chimney.....	44 25 15.18	68 59 24.41	257 46 50 337 46 40	Moose Point..... Dickey's Bluff.....	77 48 59 157 48 10	4183.8 7512.8	4575.3 8215.8	2.60 4.67
Gilmore's House, east chimney.....	44 25 50.54	68 57 37.47	276 50 40 356 38 00	Moose Point..... Dickey's Bluff.....	96 51 35 176 38 15	1736.2 8060.7	1898.7 8815.0	1.08 5.01
Searsport, tall spire.....	44 27 34.26	68 55 10.41	278 10 58 13 53 55	Cape Jellison..... Dickey's Bluff.....	98 14 00 193 52 27	5789.3 11586.3	6331.0 12670.4	3.60 7.20
Stockton, church spire.....	44 29 26.25	68 51 07.65	343 32 34 29 01 48	Castine..... Dickey's Bluff.....	163 34 20 208 57 30	11873.2 16811.3	12984.2 18384.3	7.38 10.45
Turtle Head 2, flag in tree.....	44 23 29.45	68 52 32.27	24 25 39 274 04 35	Kedear's Hill..... Castine.....	204 25 10 94 07 21	2438.0 5250.1	2438.0 5741.3	1.40 3.26
Sears Island, flag in tree.....	44 26 19.93	68 52 24.43	234 32 45 318 03 39	Cape Jellison..... Castine.....	54 33 50 138 06 19	2530.7 7573.5	2767.5 8284.3	1.57 4.71
Fort Point Light.....	44 28 00.74	68 48 22.22	63 29 02 246 00 21	Cape Jellison..... Little Ball.....	243 27 18 66 03 11	3680.7 5879.8	4025.1 6430.0	2.29 3.65
Fort Point Beacon.....	44 27 38.83	68 48 16.43	3 01 03 74 13 16	Castine..... Cape Jellison.....	183 00 50 254 11 28	8083.3 3555.1	8839.6 3887.8	5.02 2.21
Castine, Orthodox church spire.....	44 23 24.06	68 47 31.67	80 52 21 147 19 51	Castine..... Cape Jellison.....	260 51 36 327 17 31	1431.2 8171.0	1568.4 8935.6	0.89 5.08
Brooksville, church spire.....	44 23 40.22	68 45 05.47	81 21 58 28 35 34	Castine..... Bakeman's Hill.....	261 19 31 208 34 15	4704.6 5526.8	5144.8 5715.8	2.92 3.25
Jones.....	44 25 12.58	68 45 10.92	115 16 03 188 35 41	Cape Jellison..... Little Ball.....	295 12 05 8 36 17	8918.4 7664.9	9096.8 8382.1	5.17 4.76

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Penobscot Bay and River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	Metres.	Yards.	Miles.
North Castine Flagstaff.....	44 24 50.12	68 46 09.67	48 26 22 124 16 49	Castine..... Cape Jellison.....	228 24 40 304 13 32	4317.8 7531.8	4721.8 8236.6	2.68 4.68
Steel's Flagstaff.....	44 25 34.20	68 47 55.01	126 28 52 12 01 02	Cape Jellison..... Castine.....	306 26 49 192 00 34	4843.9 4320.4	5297.2 4724.6	3.02 2.68
Baker's Flagstaff.....	44 25 37.00	68 45 57.94	147 21 31 197 44 47	Webster..... Little Ball.....	327 20 53 17 45 56	2201.0 7166.5	2407.0 7837.1	1.37 4.45
Oden's Ledge Beacon.....	44 30 54.92	68 47 42.90	351 53 47 63 19 02	Webster..... Sandy Point.....	171 54 23 243 18 25	8038.9 1322.0	8791.1 1445.7	4.99 0.82
Whitmore's House, east chimney..	44 30 49.58	68 46 36.45	2 28 03 80 48 44	Webster..... Sandy Point.....	182 27 52 260 47 20	7801.2 2683.0	8531.1 2934.1	4.85 1.67
Chimney of house on Sandy Point.	44 29 54.15	68 48 17.78	281 52 44 342 36 51	Little Ball..... Webster.....	101 55 31 162 37 51	5389.3 6374.2	5893.6 6970.6	3.35 3.96
Jerry Bowden's Red House, chim- ney.	44 28 51.72	68 46 14.66	252 16 37 135 43 07	Little Ball..... Sandy Point.....	72 17 58 315 41 28	2680.8 4483.2	2931.7 4902.7	1.67 2.79
Quarry, flag in tree.....	44 30 54.45	68 44 50.31	83 24 34 144 45 53	Sandy Point..... McCloud's.....	263 21 56 324 44 27	5025.9 4699.0	5496.2 5138.6	3.12 2.92
Orland Church, tall spire.....	44 34 22.35	68 44 21.68	93 48 25 359 38 58	Mount Waldo, (B)..... Little Ball.....	273 42 07 179 39 00	11933.5 9389.4	13054.1 10268.0	7.41 5.83
Bucksport Church, east spire.....	44 34 21.53	68 47 15.68	14 15 52 349 37 42	Sandy Point..... McCloud's.....	194 14 55 169 37 57	7287.7 2690.1	7969.6 2941.8	4.53 1.67
Bucksport Church, west spire.....	44 34 24.08	68 47 19.89	13 28 50 347 21 27	Sandy Point..... McCloud's.....	193 27 56 167 21 46	7248.8 2697.6	7927.0 2950.0	4.50 1.68
Fort Knox Flagstaff.....	44 33 54.51	68 47 50.81	323 30 32 216 48 12	McCloud's..... Bucksport.....	143 31 09 36 48 46	2139.2 1935.6	2339.4 2116.7	1.33 1.20
Indian Point, flag in tree.....	44 34 46.87	68 48 14.87	272 14 56 331 35 51	Bucksport..... McCloud's.....	92 15 50 151 36 48	1691.1 3791.9	1849.3 4146.7	1.05 2.36
Winterport Church, clock spire....	44 38 09.93	68 50 28.15	245 45 20 162 44 46	Cobb's Hill..... Trevett's.....	65 46 53 342 44 30	3198.6 1725.2	3497.9 1886.6	1.99 1.07
Sparks' House, chimney.....	44 32 14.20	68 45 12.90	121 53 52 222 09 10	McCloud's..... Perry.....	301 52 42 42 10 19	2605.8 3252.0	2849.6 3556.3	1.62 2.02
Shute's Hill, flag in tree.....	44 32 29.16	68 48 13.66	201 40 45 242 45 37	Bucksport..... McCloud's.....	21 41 38 62 46 33	4502.3 1998.5	4923.6 2185.5	2.80 1.24
Deserted.....	44 33 56.29	68 48 50.60	238 53 49 276 01 18	Bucksport..... Perry.....	58 55 08 96 05 00	2894.2 7622.9	3165.0 8361.3	1.80 4.36
Belfry.....	44 38 02.24	68 49 24.53	134 34 21 41 02 42	Trevett's..... Mount Waldo, (B).....	314 33 20 220 59 56	2686.1 7959.4	2937.5 8704.2	1.67 4.95
Hopkins, flag in tree.....	44 33 50.79	68 45 48.78	137 21 57 280 51 02	Bucksport..... Perry.....	217 21 08 100 52 37	2262.8 3028.3	2474.6 3311.7	1.41 1.88
Lone Tree.....	44 37 15.29	68 49 09.54	146 03 41 339 10 43	Trevett's..... McCloud's.....	326 02 29 159 12 19	4019.6 8468.6	4395.0 9261.0	2.50 5.26
School-house, chimney.....	44 36 00.46	68 48 37.45	70 17 48 163 08 34	Mount Waldo, (B)..... Treat's.....	250 14 29 283 06 45	6654.8 3512.7	7277.4 3841.4	4.14 2.18
South Orrington, church spire.....	44 41 33.78	68 48 40.81	333 40 42 26 17 27	Cobb's Hill..... Mount Waldo, (B).....	173 41 00 206 14 10	5009.1 13977.1	5477.8 15285.0	3.11 8.68
Orrington, church spire.....	44 43 50.67	68 49 12.52	352 15 54 18 08 40	Cobb's Hill..... Mount Waldo, (B).....	172 16 34 198 05 45	9288.2 17633.9	10157.3 19283.9	5.77 10.96
Hampden, church tower 1.....	44 43 30.91	68 50 14.95	343 00 36 14 17 38	Cobb's Hill..... Mount Waldo, (B).....	163 02 00 194 15 27	8985.7 16664.1	9826.5 18223.4	5.58 10.35
Hampden, church tower 2.....	44 44 20.89	68 49 59.04	347 20 57 14 09 57	Cobb's Hill..... Mount Waldo, (B).....	167 22 10 194 07 35	10388.5 18245.4	11360.6 19952.6	6.45 11.33
Hampden, church tower 3.....	44 44 27.69	68 49 57.46	347 46 54 14 06 40	Cobb's Hill..... Mount Waldo, (B).....	167 48 05 194 04 17	10585.9 18457.7	11576.5 20184.8	6.58 11.46
Chimney of house on west side of river.	44 35 25.20	68 49 40.12	166 52 16 132 46 28	Trevett's..... Treat's.....	346 51 26 312 45 23	6012.5 3037.5	7559.3 3037.5	4.30 1.73
Bangor, Methodist church.....	44 48 20.39	68 45 41.66	93 03 25 321 57 57	Thomas' Hill..... Saunders' Mount.....	273 02 45 142 04 47	1961.2 2832.7	1379.2 29782.1	0.78 12.95
<i>Penobscot bay and St. George's river.</i>								
RAGGED MOUNT.....	44 12 43.95	69 08 43.55						
MOUNT DESERT.....	44 21 03.86	68 13 15.48	78 30 46	Ragged Mount.....	257 52 03	7532.4	82435.9	46.84
Isle au Haut.....	44 04 01.90	68 36 42.51	110 51 38 224 35 04	Ragged Mount..... Mount Desert.....	290 29 20 44 51 25	45632.8 44388.1	49902.7 48541.5	28.35 27.58

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Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	Metres.	Yards.	Miles.
Woodenball.....	43 51 27.62	68 48 17.90	213 35 34 145 24 19	Isle au Haut..... Ragged Mount.....	33 43 37 325 10 07	27966.6 47917.7	30583.4 52401.3	17.38 29.77
Turkey Church.....	43 56 45.12	69 14 21.03	254 46 56 194 12 16	Isle au Haut..... Ragged Mount.....	75 13 05 14 16 11	52081.6 30528.7	56954.8 33385.2	32.56 18.97
Fox Rocks.....	44 06 26.90	68 52 21.53	118 10 08 348 54 28	Ragged Mount..... Wooden Ball.....	297 58 44 168 57 18	24726.7 28278.5	27040.3 30624.5	15.37 17.57
Hurricane.....	44 02 06.21	68 53 06.20	133 25 46 341 55 20	Ragged Mount..... Woodenball.....	313 14 54 161 58 40	28650.5 20747.3	31331.3 22688.6	17.81 12.89
High Island.....	44 00 47.73	69 03 15.24	63 17 08 259 44 11	Turkey Church..... Hurricane.....	243 09 26 79 51 14	16619.8 13779.8	18174.9 15069.2	10.33 8.56
Green Mount.....	43 54 10.16	69 00 08.39	287 28 45 104 11 37	Wooden Ball..... Turkey Church.....	107 36 57 284 01 45	16634.0 19610.5	18190.5 21445.4	10.34 12.18
St. George's Church.....	44 01 10.06	69 11 48.98	22 31 27 273 23 48	Turkey Church..... High Island.....	202 29 42 93 29 45	8851.0 11462.3	9679.2 12534.2	5.50 7.12
Bear Hill.....	44 08 38.11	69 06 03.18	345 32 56 304 52 08	High Island..... Hurricane.....	165 34 53 125 01 09	14990.3 21083.7	16392.9 23056.5	9.31 13.10
Metinic.....	43 53 35.98	69 07 13.90	156 23 30 201 44 43	St. George's Church..... High Island.....	336 20 19 21 47 29	15296.3 14347.2	16727.6 15689.7	9.50 8.91
Ingraham.....	44 04 55.76	69 06 31.35	330 17 09 185 12 31	High Island..... Bear Hill.....	150 19 25 5 12 51	8812.3 6890.8	9636.9 7535.6	5.48 4.28
Post Hill.....	44 05 10.52	69 04 15.15	81 28 28 159 27 29	Ingraham..... Bear Hill.....	261 26 53 339 26 14	3063.6 6842.4	3350.2 7482.6	1.90 4.25
False White Head.....	43 59 52.35	69 06 23.08	178 52 29 196 09 42	Ingraham..... Post Hill.....	358 52 23 16 11 11	9365.7 10231.5	10242.0 11180.1	5.82 6.35
Norton's Island.....	43 58 59.80	69 08 16.18	352 04 48 62 57 40	Metinic..... Turkey Church.....	172 05 32 242 53.27	10089.0 9133.4	11039.0 9988.0	6.27 5.67
Jameson.....	44 07 01.71	69 04 44.00	349 24 18 149 24 08	Post Hill..... Bear Hill.....	169 24 38 329 23 13	3491.7 3457.1	3818.5 3780.6	2.17 2.15
Little Green, (third-order signal)...	43 54 50.91	69 01 48.43	72 22 14 220 49 02	Metinic..... Hurricane.....	252 18 28 40 55 05	7621.5 17787.5	8334.6 19451.9	4.74 11.05
Tenant's Harbor Church.....	43 57 58.58	69 12 43.31	191 34 21 43 52 05	St. George's Church..... Turkey Church.....	11 34 59 223 50 57	6032.4 3144.4	6596.8 3438.6	3.75 1.95
Tenant's Harbor Light.....	43 57 38.90	69 10 45.74	231 08 51 167 48 21	Norton's Island..... St. George's Church.....	53 10 35 347 47 37	4164.4 6867.5	4554.0 7291.4	2.59 4.14
Herring Gut Island.....	43 55 21.62	69 15 51.58	218 04 32 285 42 35	Turkey Church..... Metinic.....	38 05 35 105 48 34	3273.3 12001.6	3579.6 13124.5	2.03 7.46
Herring Gut Light.....	43 55 01.57	69 15 20.80	12 08 16 283 36 59	Monhegan..... Metinic.....	192 06 28 103 42 37	16610.9 11180.5	18165.2 12226.6	10.32 6.95
Heron Neck Light.....	44 01 29.70	68 51 23.16	85 23 54 116 32 53	High Island..... Hurricane.....	265 15 38 296 31 41	15909.7 2864.4	17398.4 2804.3	9.89 1.59
Owl's Head Light.....	44 05 30.76	69 02 18.93	8 09 48 139 14 56	High Island..... Bear Hill.....	188 09 09 319 12 20	8824.7 7633.4	9650.4 8347.6	5.48 4.74
Shears on Peabody's Island.....	43 59 16.98	69 04 04.48	171 20 27 250 15 37	Bear Hill..... Hurricane.....	351 19 05 70 23 14	17517.9 15369.7	19157.9 17026.5	10.88 9.67
Matinicus East Light.....	43 46 59.75	68 50 57.73	119 22 21 203 20 09	Metinic..... Wooden Ball.....	299 11 05 23 22 00	24997.2 9007.3	27336.2 9850.1	15.53 5.60
Matinicus West Light.....	43 47 01.16	68 50 59.13	174 13 17 153 37 36	Hurricane..... Ragged Mount.....	354 11 49 333 25 17	28093.8 53191.6	30722.6 58168.7	17.46 33.05
White Head Light.....	43 58 42.25	69 07 07.58	251 17 59 233 10 45	Hurricane..... High Island.....	71 27 44 53 13 20	19775.8 6464.4	21626.2 7069.3	12.28 4.02
Brown's Head Light.....	44 06 41.29	68 54 14.28	47 51 44 102 57 09	High Island..... Bear Hill.....	227 45 28 282 48 55	16247.0 16165.9	17767.3 17678.6	10.10 10.04
Lone Tree on Beach Hill.....	44 10 05.13	69 05 50.96	141 59 58 348 35 54	Ragged Mount..... High Island.....	321 57 58 108 37 42	6223.6 17547.5	6805.9 19189.4	3.87 10.90
Fiddler's Ledge, stone beacon.....	44 06 04.77	68 56 02.23	44 36 11 331 54 11	High Island..... Hurricane.....	294 21 10 151 56 14	13732.8 8322.9	15017.8 9101.7	8.53 5.17
Saddleback Light.....	44 00 50.62	68 43 15.24	21 15 38 235 56 08	Woodenball..... Isle au Haut.....	201 12 08 56 00 41	18640.3 10548.8	20384.4 11535.8	11.58 6.55
Dix Island, unpainted house, tall chimney in centre.	44 00 36.39	69 03 54.06	248 16 39 156 28 15	High Island..... Ingraham.....	68 17 06 336 26 26	945.3 8731.7	1033.7 9548.8	0.59 5.43
Beale's House, chimney.....	44 00 41.95	69 03 59.48	64 26 24 259 44 49	False White Head..... High Island.....	244 24 44 79 45 20	3546.1 1001.7	3877.9 1095.5	2.20 0.62

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Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tances.
	° ' "	° ' "	° ' "		° ' "	Metres.	Yards.	Miles.
Large House, north chimney.....	43 59 48.88	69 06 40.49	254 29 24 54 36 57	False White Head	74 29 36	402.8	440.5	0.25
				Norton's Island	234 35 50	2615.7	2860.4	1.63
White Head Island, east chimney of house.	43 58 57.02	69 07 35.82	126 04 55 65 46 42	St. George's Church	306 01 59	6975.7	7628.4	4.33
				Turkey Church.....	245 42 01	9907.3	10834.3	6.16
Smalley's Hill, flag.....	43 59 16.25	69 12 42.59	0 23 11 198 46 25	Tenant's Harbor Church.....	180 23 10	2397.3	2621.6	1.49
				St. George's Church	18 47 02	3709.6	4056.7	2.30
Widow Ellena Hart's House, centre chimney.	43 57 34.30	69 12 09.87	135 09 50 62 34 52	Tenant's Harbor Church	315 09 27	1056.9	1155.7	0.66
				Turkey Church	242 33 21	3294.6	3602.8	2.05
Hart's Neck, flag in tree.....	43 57 09.75	69 11 29.69	132 34 07 78 45 45	Tenant's Harbor Church.....	312 33 16	2228.1	2436.6	1.36
				Turkey Church.....	258 43 46	3895.2	4259.7	2.42
Island, north of Tenant's Harbor light, flag in tree.	43 58 16.07	69 10 42.95	60 01 08 247 33 40	Turkey Church.....	239 58 37	5613.8	6139.1	3.49
				Norton's Island	67 35 22	3538.3	3869.4	2.20
Seavey's Hill, flag in tree	43 59 09.76	69 11 46.97	273 43 30 29 45 40	Norton's Island	93 45 57	4707.1	5147.6	2.93
				Tenant's Harbor Church	209 45 01	2530.0	2766.7	1.57
Russell's Hill, flag in tree	43 57 35.39	69 14 37.23	346 52 21 254 15 08	Turkey Church.....	166 52 32	1592.9	1742.0	0.99
				Tenant's Harbor Church.....	74 16 37	2638.2	2885.1	1.64
Fogg's Hill, No. 1, flag in tree	44 00 26.48	69 07 53.05	297 42 46 104 22 47	False White Head	117 43 49	2263.3	2475.1	1.41
				St. George's Church.....	281 20 03	5423.3	5930.7	3.37
Fogg's Hill, No. 2, flag in tree	44 00 26.77	69 07 45.75	14 10 18 299 37 31	Norton's Island	194 09 57	2768.5	3027.5	1.72
				False White Head	119 58 28	2125.6	2324.5	1.32
Joseph Clark's House, chimney in centre.	43 57 16.20	69 12 43.25	179 56 35 66 15 22	Tenant's Harbor Church.....	359 56 35	1307.8	1430.1	0.81
				Turkey Church.....	246 14 14	2381.9	2604.8	1.48
Enoch Clark's Barn, centre.....	43 57 05.20	69 12 45.54	239 28 14 189 27 48	Norton's Island	59 31 21	6968.2	7620.2	4.33
				St. George's Church	9 28 27	7661.0	8377.8	4.76
Centre of Barn, near middle penin- sula.	44 00 58.69	69 10 27.49	118 03 34 35 51 12	St. George's Church	298 04 37	2057.0	2249.5	1.28
				Turkey Church.....	215 48 30	8890.9	9722.8	5.52
Post Hill, yellow house chimney...	44 05 09.10	69 04 17.55	160 00 13 82 08 04	Bear Hill.....	339 58 59	6864.7	7507.0	4.27
				Ingraham	262 06 31	3004.4	3285.5	1.87
Flag in tree near Post Hill	44 05 14.20	69 04 04.33	80 08 49 64 39 57	Ingraham	260 07 07	3319.3	3629.9	2.06
				Post Hill	244 39 50	265.8	290.6	0.16
Norton's Island, flag in tree.....	43 58 54.94	69 08 09.00	133 15 27 204 09 47	Norton's Island	313 15 22	218.9	239.3	0.14
				Post Hill	24 12 30	12706.0	13894.9	7.90
Mosquito Island, flag in tree	43 55 03.11	69 12 52.46	147 53 46 289 33 29	Turkey Church.....	327 52 45	3715.5	4063.1	2.31
				Metinic.....	109 37 24	8018.4	8768.7	4.98
Hewett's Island, flag in tree	43 59 34.54	69 03 47.30	99 00 54 197 33 22	False White Head	278 59 06	3513.8	3842.6	2.18
				High Island	17 33 44	2568.9	2800.5	1.47
Rackley's Island, flag in tree	44 00 09.04	69 02 36.89	84 11 15 144 26 31	False White Head	264 08 38	5065.0	5539.0	3.15
				High Island	324 26 04	1467.9	1605.2	0.91
Rackley's Island, third-order signal	43 59 54.35	69 02 45.43	89 17 24 158 03 27	False White Head	269 14 53	4849.2	5303.0	3.01
				High Island	338 03 06	1775.8	1941.9	1.10
Crescent Island, third-order signal..	44 01 18.13	69 01 48.11	155 29 05 136 50 34	Post Hill	335 27 23	7883.0	8620.6	4.90
				Ingraham	316 47 17	9211.6	10073.5	5.72
Harrington's Hill, flag in tree.....	44 01 39.87	69 07 55.66	338 08 04 217 01 45	False White Head	148 09 08	3906.6	4272.1	2.43
				Post Hill	37 04 18	8145.1	8907.3	5.06
Captain Crockett's House, north- east chimney.	43 59 20.87	69 04 05.16	107 33 36 202 32 04	False White Head	287 32 00	3222.9	3524.4	2.00
				High Island	22 32 39	2991.6	3173.0	1.80
Pleasant Island, flag in tree	43 58 57.80	69 05 14.81	137 54 48 90 53 10	False White Head	317 54 01	2269.8	2482.2	1.41
				Norton's Island	270 51 04	4042.1	4420.3	2.51
Thorndike's Hill, flag in tree	44 01 47.23	69 06 39.39	181 45 44 354 09 00	Ingraham	1 45 50	5821.3	6366.0	3.62
				False White Head	174 09 11	3563.7	3897.1	2.21
Fisherman's Island, flag	44 02 30.30	69 01 55.56	147 52 23 29 16 24	Post Hill	327 50 46	5839.6	6386.0	3.63
				High Island	209 15 29	3628.7	3968.2	2.25
Red School-house, chimney.....	44 04 35.47	69 05 46.00	241 50 44 121 50 37	Post Hill	61 51 47	2992.5	3257.0	1.42
				Ingraham	301 50 06	1187.4	1298.5	0.74
Sheep Island, flag in tree.....	44 03 48.50	69 02 43.15	7 17 56 141 02 42	High Island	187 17 34	5624.2	6150.5	3.49
				Post Hill	321 01 38	3255.2	3539.8	2.02
Ash Island, white flag in tree.....	44 02 24.57	69 03 52.76	35 29 37 42 53 49	False White Head	215 27 52	5768.1	6307.9	3.58
				Norton's Island	222 50 46	8623.1	9130.0	5.35
Ash Point, flag in tree.....	44 02 48.34	69 04 23.81	26 04 17 144 11 37	False White Head	206 02 54	6045.8	6611.5	3.76
				Ingraham	324 10 08	4849.5	5303.3	3.01
Garden Island Ledge, red spindle, with one bull.	44 00 45.85	69 05 25.12	38 02 01 268 50 30	False White Head	218 01 21	2086.0	2292.2	1.30
				High Island	88 52 00	2293.5	2514.2	1.80

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	° ' "	° ' "	° ' "		° ' "	Metres.	Yards.	Miles.
Otter Island Ledge, black spindle, with two balls.	44 01 29.24	69 04 30.53	39 59 25 307 22 13	False White Head	219 58 07	3901.9	4267.0	2.42
Jameson's Point, chimney of white house.	44 06 59.54	69 04 51.06	152 13 09 247 02 05	High Island	127 23 05	2110.2	2307.6	1.31
Rockland Steam Mill, tall chimney	44 06 28.23	69 06 16.97	311 30 33 243 25 41	Bear Hill	332 12 19	3438.6	3760.3	2.14
First Baptist Church, clock-faced ..	44 06 49.57	69 06 09.44	258 48 43 182 22 41	Jameson	67 02 10	170.6	186.6	0.11
Methodist Church	44 06 10.11	69 06 19.97	233 15 26 184 40 08	Post Hill	131 31 58	3618.7	3957.3	2.25
Episcopal Church	44 06 06.05	69 06 32.11	234 26 23 187 48 13	Jameson	63 26 46	2310.8	2527.0	1.44
Baptist Church	44 06 21.16	69 06 14.96	238 13 58 7 52 09	Bear Hill	78 49 43	1935.8	2116.9	1.20
Congregationalist Church	44 06 22.52	69 06 15.59	7 27 39 183 46 21	Jameson	2 22 45	3352.5	3666.2	2.08
Church, cupola	44 07 06.68	69 05 49.73	12 53 52 275 57 24	Bear Hill	53 16 33	2662.6	2911.7	1.65
White Spire Vane, heart and ar- rows.	44 06 12.80	69 06 20.34	184 51 38 304 36 48	Jameson	4 40 20	4382.5	5011.2	2.85
Roman Catholic Church	44 06 05.77	69 06 42.27	190 28 03 297 31 00	Bear Hill	54 27 38	2954.7	3231.1	1.84
Unpainted House, chimney in centre.	44 02 47.95	69 04 46.36	331 18 59 188 57 55	Bear Hill	7 48 33	4736.5	5179.7	2.94
Dodge Homestead, south chimney ..	44 08 09.90	69 07 30.15	337 24 24 245 43 59	Jameson	58 15 01	2378.2	2600.8	1.48
Centre of dark barn on hill-side.	44 07 10.91	69 07 48.97	307 59 06 273 55 39	Ingraham	187 51 58	2600.5	2809.4	1.65
Rockport, Universalist church	44 11 02.79	69 04 11.64	117 22 20 29 02 18	Ingraham	187 27 28	2699.9	2952.5	1.68
Rockport, Congregationalist church, square spire.	44 11 14.78	69 03 46.64	112 41 15 32 06 49	Bear Hill	3 46 30	4193.4	4585.6	2.61
Edwin Ojier's House	44 11 53.17	69 03 18.46	102 17 04 31 18 24	Jameson	102 53 23	4145.4	4533.3	2.58
Raccoon	44 00 31.11	69 16 37.23	259 21 52 336 27 20	Jameson	95 58 10	1408.6	1606.0	0.91
Smith	44 03 15.82	69 14 07.73	33 13 56 321 26 33	Bear Hill	4 51 50	4501.2	4922.4	2.80
Hall	44 02 47.92	69 10 19.12	99 37 34 33 30 23	Post Hill	124 38 15	3383.8	3700.5	2.10
Watts	43 59 35.72	69 13 19.35	14 37 05 214 40 13	Bear Hill	10 28 30	4781.7	5229.2	2.97
Stone	44 02 00.85	69 12 16.93	241 00 04 338 15 23	Post Hill	117 32 43	3690.1	4035.4	2.29
Otis	43 58 57.34	69 14 43.22	223 27 49 138 44 06	High Island	151 20 02	4928.9	4624.6	2.63
Recess	44 03 55.75	69 11 31.44	70 30 19 322 25 58	Post Hill	8 58 17	4454.2	4871.0	2.77
Rivers's House, north chimney	43 59 50.91	69 15 01.81	240 21 39 120 16 44	High Island	157 27 21	14777.9	16160.6	9.18
South Thomaston, white spire	44 03 08.91	69 06 57.43	189 58 08 262 26 08	Bear Hill	65 45 00	2119.9	2318.2	1.32
Thomaston, one-story octagonal cu- pola.	44 04 45.97	69 10 12.87	17 48 35 266 28 15	Post Hill	128 01 35	6034.7	6599.3	3.75
Thomaston Church, tall spire, with green blinds.	44 04 48.74	69 09 45.76	11 18 06 63 50 03	Jameson	93 57 48	4121.9	4507.6	2.56
Thomaston Church, two-story oc- tagonal spire, with pillars.	44 04 45.43	69 10 15.76	61 50 32 1 13 34	Ragged Mount	297 19 11	6796.4	7432.3	4.22
Thomaston, small church, low spire.	44 04 43.24	69 10 32.98	60 34 30 355 06 18	Bear Hill	209 01 00	5106.0	5584.4	3.17
Thomaston Church, tall white spire.	44 04 36.07	69 10 38.81	61 58 08 352 34 15	Ragged Mount	292 37 48	7143.2	7811.6	4.44
				Bear Hill	212 05 14	5707.9	6241.9	3.55
				Ragged Mount	382 13 17	7585.0	8076.0	4.59
				Bear Hill	211 16 29	7044.5	7703.6	4.38
				St. George's Church	79 25 12	6533.8	7145.2	4.06
				Turkey Church	156 28 55	7606.4	8318.1	4.73
				Raccoon	213 12 12	6076.0	6644.6	3.78
				St. George's Church	141 28 10	4961.3	5425.5	3.08
				Smith	279 34 55	5160.8	5643.7	3.21
				St. George's Church	213 29 21	3620.7	3959.5	2.25
				Turkey Church	194 36 22	5440.8	5949.9	3.38
				St. George's Church	34 41 16	3541.3	3872.6	2.20
				Hall	61 01 26	2998.1	3278.7	1.86
				St. George's Church	158 15 43	1687.3	1845.2	1.05
				St. George's Church	43 29 50	5644.8	6172.9	3.51
				Raccoon	318 42 47	3850.3	4210.5	2.39
				Smith	250 28 30	3690.0	4035.3	2.29
				Hall	142 26 48	2640.7	2887.8	1.64
				St. George's Church	60 23 53	4943.5	5406.0	3.07
				Raccoon	300 15 38	2461.0	2691.3	1.53
				Ingraham	9 58 26	3347.3	3660.5	2.08
				Jameson	22 27 41	7774.7	8502.1	4.83
				St. George's Church	197 47 28	6998.4	7653.1	4.35
				Ingraham	86 30 49	4937.6	5399.6	3.07
				Hall	191 17 43	3803.3	4159.2	2.36
				Smith	243 47 01	6500.2	7102.4	4.04
				Smith	241 47 51	5860.0	6408.3	3.64
				Hall	181 13 32	3628.8	3968.3	2.25
				Smith	240 32 01	5492.1	6006.0	3.41
				Hall	175 06 27	3573.7	3908.0	2.22
				Smith	241 55 43	5271.4	5764.6	3.28
				Hall	172 34 28	3368.0	3683.1	2.09

REPORT OF THE SUPERINTENDENT OF
UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Penobscot Bay and St. George's River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	Metres.	Yards.	Miles.
Thomaston Church, low spire, with dome roof, clock-face.	44 04 41.28	69 10 44.40	59 47 20 350 54 46	Smith..... Hall.....	239 44 58 170 55 03	5241.0 3543.2	5731.4 3875.4	3.26 2.20
Thomaston Church.....	44 04 36.56	69 10 56.87	59 37 01 345 55 02	Smith..... Hall.....	239 34 48 165 55 28	4924.1 3456.3	5384.9 3779.7	3.06 2.15
Cushing Church, No. 1.....	43 59 42.75	69 16 37.40	180 02 11 330 59 15	Raccoon..... Turkey Church.....	0 02 11 151 00 50	1492.4 6268.0	1632.0 6854.4	0.93 3.89
Cushing Church, No. 2.....	44 00 53.66	69 14 43.10	190 08 39 74 41 00	Smith..... Raccoon.....	10 09 03 254 39 41	4456.0 2637.9	4873.0 2884.7	2.77 1.64
Brown's Hill.....	44 04 03.89	69 10 48.63	344 20 50 75 13 28	Hall..... Recess.....	164 21 10 255 12 38	2434.9 985.3	2662.8 1077.5	1.51 0.61
Farm-house, centre chimney.....	44 03 52.41	69 09 19.21	33 49 19 100 06 19	Hall..... Brown's Hill.....	213 48 37 280 05 17	2395.8 2021.2	2619.9 2210.3	1.49 1.26
Fisherman's East Gable.....	44 03 40.32	69 11 03.24	206 55 06 327 35 36	Brown's Hill..... Hall.....	26 55 18 147 36 08	816.0 1915.5	892.4 2094.7	0.51 1.19
Burton's Hill.....	44 01 35.02	69 12 33.51	233 16 20 308 24 05	Hall..... St. George's Church.....	53 17 53 128 24 36	3732.4 1268.5	4081.6 1387.2	2.32 0.79
Blank Point.....	44 00 49.68	69 12 31.47	178 09 50 236 25 07	Burton's Hill..... St. George's Church.....	358 09 49 56 25 37	1418.5 1138.7	1551.2 1245.2	0.88 0.71
Foundation Hill.....	43 59 40.36	69 13 33.62	110 58 18 220 06 25	Raccoon Point..... St. George's Church.....	290 56 10 40 07 38	4379.8 3621.4	4789.6 3960.2	2.72 2.25
Fort St. George.....	44 01 27.68	69 12 06.90	30 15 33 112 58 10	Foundation Hill..... Burton's Hill.....	210 14 33 292 27 52	3834.2 641.2	4193.0 701.2	2.38 0.40
Narrows.....	43 59 04.22	69 15 16.03	146 00 16 243 56 39	Raccoon Point..... Foundation Hill.....	325 59 20 63 57 50	3234.6 2539.8	3537.2 2777.4	2.01 1.58
Stone Point.....	43 58 18.56	69 16 12.56	172 21 02 234 30 15	Raccoon Point..... Foundation Hill.....	352 20 45 54 32 05	4127.5 4349.3	4513.7 4756.3	2.56 2.70
J. Stone's House, centre chimney..	43 58 16.51	69 16 21.91	175 18 18 235 22 38	Raccoon Point..... Foundation Hill.....	355 18 07 55 24 35	4167.9 4556.2	4557.8 4982.5	2.59 2.83
Hornbarn Hill.....	43 58 39.17	69 17 38.94	250 55 16 288 16 42	Foundation Hill..... Stone Point.....	70 58 06 108 17 42	5783.5 2027.1	6324.6 2216.8	3.59 1.26
Maple Hill.....	43 58 44.76	69 17 10.21	192 37 07 237 54 11	Raccoon Point..... St. George's Church.....	12 37 30 57 57 54	3363.1 8447.3	3677.8 9247.7	2.09 5.25
Hathorn Hill.....	43 58 51.86	69 16 41.66	181 50 49 72 58 02	Raccoon Point..... Hornbarn Hill.....	1 50 52 252 57 22	3064.0 1335.3	3350.7 1460.2	1.90 0.83
Adam Teal's House, centre chimney.	43 58 06.57	69 14 55.50	120 35 36 102 10 03	Hathorn Hill..... Stone Point.....	300 34 22 282 09 09	2747.4 1757.6	3004.5 1922.0	1.71 1.09
Friendship.....	43 59 52.39	69 17 50.66	223 50 38 336 38 24	Raccoon Point..... Maple Hill.....	53 51 25 156 38 52	2025.7 2273.1	2215.2 2485.8	1.26 1.41
J. Seavey's House, centre chimney..	43 59 11.75	69 16 20.54	353 49 28 37 26 37	Stone Point..... Hathorn Hill.....	173 49 33 217 26 22	1651.0 773.4	1805.5 845.7	1.03 0.48
<i>Muscongus Bay, from Penobscot Bay to Damariscotta River.</i>								
Monhegan.....	43 46 15.39	69 17 56.93						
Edgecombe.....	43 57 12.25	69 35 56.91	309 56 48	Monhegan.....	130 09 16	31503.3	34451.0	19.57
Turkey Church.....	43 56 45.12	69 14 21.03	13 57 17 91 47 11	Monhegan..... Edgecombe.....	193 54 47 271 32 12	20022.4 28906.0	21895.9 31610.8	12.44 17.96
Kenniston.....	43 53 02.45	69 36 54.29	189 24 59 296 11 30	Edgecombe..... Monhegan.....	9 25 39 116 24 55	7815.1 28345.9	8546.4 30906.2	4.86 17.62
Damiscove.....	43 45 15.64	69 36 26.24	177 30 42 265 38 18	Kenniston..... Monhegan.....	357 30 22 85 51 26	14419.0 24879.8	15768.1 27297.8	8.96 15.46
Parker's Island.....	43 49 21.49	69 43 40.90	233 03 22 307 56 20	Kenniston..... Damiscove.....	53 08 10 128 01 20	11355.5 12327.9	12418.0 13481.4	7.06 7.66
Pemmaquid.....	43 51 44.94	69 29 57.32	302 12 45 245 59 49	Monhegan..... Turkey Church.....	122 21 02 66 10 38	19041.5 22854.0	20823.2 24992.2	11.83 14.20
White Island.....	43 47 13.33	69 34 05.71	274 37 31 213 29 09	Monhegan..... Pemmaquid.....	94 48 41 33 32 01	21735.9 10052.3	23769.7 10992.9	13.51 6.25
Davis.....	43 54 31.37	69 22 40.31	62 16 23 48 37 11	Pemmaquid..... White Island.....	242 11 20 228 29 16	11023.9 20421.3	12055.4 22332.1	6.85 12.69
Johnston.....	44 00 48.60	69 25 27.56	64 36 32 342 13 30	Edgecombe..... Davis.....	244 29 15 162 15 26	15530.7 12224.8	16983.9 13368.6	9.65 7.60
Blin.....	44 07 13.33	69 40 30.64	300 29 24 341 47 02	Johnston..... Edgecombe.....	120 39 52 161 50 12	22341.1 19523.8	25525.1 21350.7	14.51 12.13

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Muscongus Bay.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	Metres.	Yards.	Miles.
Gull	43 52 39.19	69 24 37.35	76 50 32 217 01 29	Pemmaquid	256 46 50	7337.1	8023.7	4.56
				Davis	37 02 50	4337.0	4742.8	2.69
Reed	43 49 28.12	69 34 25.88	353 48 43 153 24 24	White Island	173 48 57	4183.8	4575.3	2.60
				Kenniston	333 22 41	7398.7	8091.0	4.60
Auld	43 53 11.89	69 35 11.25	290 53 58 82 51 51	Pemmaquid	110 57 36	7503.1	8205.2	4.66
				Kenniston	262 50 40	2317.1	2533.9	1.44
Caldwell	43 56 14.93	69 17 21.84	256 58 16 65 48 22	Turkey Church	77 00 21	4139.2	4526.5	2.37
				Davis	245 44 41	7789.2	8518.1	4.84
Muscongus	43 58 41.69	69 26 23.46	197 37 47 327 11 32	Johnston	17 38 26	4110.0	4494.6	2.55
				Davis	147 14 07	9189.2	10049.1	5.71
Dodge	43 55 33.46	69 35 46.09	18 04 92 175 28 56	Kenniston	198 03 35	4901.1	5359.7	3.05
				Edgecombe	355 28 49	3059.5	3345.8	1.90
Captain Childs's Cupola	43 53 01.77	69 31 03.83	26 37 38 20 42 46	Damiscove	206 33 55	16086.4	17591.6	9.99
				White Island	200 40 40	11494.4	12569.9	7.14
Square House	43 53 17.45	69 29 45.13	131 11 20 5 26 09	Edgecombe	311 07 02	11013.4	12043.9	6.84
				Pemmaquid	185 26 01	2867.3	3135.6	1.78
Muscongus Island, white chimney ..	43 55 14.40	69 25 11.74	44 37 14 350 53 58	Pemmaquid	224 33 56	9077.3	9926.7	5.64
				Gull	170 54 22	4850.5	5304.3	3.01
Cranberry Island, chimney	43 56 16.40	69 20 47.54	37 49 18 120 56 42	Davis	217 48 00	4102.8	4486.7	2.55
				Muscongus	300 52 49	8728.4	9545.1	5.42
Cranberry, signal	43 56 03.38	69 21 22.50	55 16 43 31 26 52	Pemmaquid	235 10 46	13985.0	15283.6	8.69
				Davis	211 25 58	3328.0	3639.3	2.07
Carter's Island, tree	43 53 46.50	69 25 48.06	392 46 13 56 02 02	Gull	142 47 02	2609.1	2853.3	1.62
				Pemmaquid	235 59 09	6710.6	7338.6	4.17
Crow	43 55 32.73	69 22 06.37	99 30 09 155 19 02	Edgecombe	279 20 33	18773.1	20529.7	11.66
				Johnston	335 16 42	10729.8	11733.8	6.67
Marsh	43 54 37.28	69 23 40.44	57 44 00 277 43 16	Pemmaquid	237 39 39	9352.5	10283.7	6.18
				Davis	97 43 58	1354.4	1481.1	0.84
Otter Island, chimney	43 55 59.15	69 20 14.09	58 58 35 50 18 09	Pemmaquid	238 51 51	15196.3	16618.2	9.44
				Davis	230 16 28	4239.6	4636.3	2.63
Franklin Light	43 53 30.81	69 22 09.64	72 40 02 337 10 53	Pemmaquid	252 34 38	10939.8	11963.4	6.80
				Monhegan	157 13 42	14574.5	15938.2	9.06
Thompson	43 53 57.56	69 18 47.07	228 54 24 75 45 51	Turkey Church	48 57 29	7871.9	8698.5	4.89
				Pemmaquid	254 38 06	15509.7	16969.9	9.64
Barn on Davis Island, west gable ..	43 53 21.26	69 17 58.57	79 34 25 81 44 28	Pemmaquid	259 26 07	16317.6	17844.4	10.14
				Gull	261 39 52	8995.6	9837.3	5.39
Harbor	43 52 36.17	69 18 04.09	84 24 02 65 12 49	Pemmaquid	264 15 48	16000.9	17498.1	9.94
				White Island	245 01 43	23680.6	25896.4	14.71
Allen	43 52 13.88	69 18 23.20	86 46 07 126 30 17	Pemmaquid	266 38 06	15523.3	16973.8	9.65
				Davis	306 27 19	7136.1	7803.9	4.43
Burnt Island	43 51 59.01	69 17 21.97	88 35 58 123 31 35	Pemmaquid	268 27 15	16870.8	18449.4	10.48
				Davis	303 27 49	8519.4	9316.6	5.29
Monhegan Fog-bell	43 45 46.43	69 19 16.41	127 44 47 164 18 58	Pemmaquid	307 37 23	18098.0	19791.4	11.24
				Davis	344 16 37	16827.9	18402.4	10.46
Thrumbeap	43 49 16.55	69 32 37.37	34 33 37 27 27 10	Damiscove	214 30 59	9024.9	9869.4	5.61
				White Island	207 26 09	4284.5	4685.4	2.66
Damiscove, white flag	43 46 32.59	69 36 13.42	246 13 40 221 02 38	White Island	66 15 08	3119.5	3411.4	1.94
				Pemmaquid	41 06 58	12788.8	13985.4	7.95
Rutherford's Island	43 51 15.88	69 33 02.11	122 25 04 10 45 26	Kenniston	302 22 23	6138.1	6712.5	3.81
				White Island	190 44 42	7617.8	8330.6	4.73
Hodgden's Mills, chimney	43 52 01.67	69 34 50.00	274 29 09 124 04 33	Pemmaquid	94 32 32	6555.1	7168.5	4.07
				Kenniston	304 03 07	3348.3	3661.6	2.08
Bristol, red flag	43 52 01.70	69 33 14.22	110 54 54 276 41 10	Kenniston	290 52 22	5256.9	5748.8	3.27
				Pemmaquid	96 43 26	4425.9	4840.1	2.75
John's Island, flag	43 51 57.35	69 31 43.17	279 11 19 19 59 06	Pemmaquid	99 12 39	2394.0	2618.0	1.49
				White Island	199 57 27	9324.9	10197.5	5.79
Pemmaquid Point, chimney of house.	43 51 02.02	69 29 13.29	253 35 45 300 16 05	Davis	53 40 17	10894.1	11913.5	6.77
				Monhegan	120 23 53	17512.4	19151.0	10.88
House with red chimney	43 54 59.13	69 25 53.96	326 33 31 338 24 14	Monhegan	146 39 01	19358.7	21170.1	12.02
				Gull	158 25 07	4644.4	5079.0	2.89
McGee	43 54 46.82	69 18 29.59	85 09 24 236 36 44	Davis	265 06 30	5614.3	6139.6	3.49
				Turkey Church	56 39 36	6640.1	7261.4	4.13

REPORT OF THE SUPERINTENDENT OF
UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Muscongus Bay.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	<i>Metros.</i>	<i>Yards.</i>	<i>Miles.</i>
Church at Herring Gut.....	43 55 42.70	69 14 59.55	12 45 51 77 57 28	Monhegan	192 43 48	17949.4	19628.9	11.15
				Davis	257 52 09	10511.7	11495.3	6.53
Edgecombe, tall tree.....	43 57 35.54	69 36 59.11	297 90 31 359 15 34	Edgecombe	117 21 14	1561.5	1707.6	0.97
				Kenniston	179 15 37	8427.8	9216.4	5.24
White Chimney of large house ...	43 55 48.94	69 33 06.79	29 48 27 44 40 18	Auld	200 47 01	5588.1	6111.0	3.47
				Kenniston	224 37 40	7221.6	7897.3	4.49
Sproul	43 54 35.31	69 33 16.60	59 28 21 44 46 28	Kenniston	239 25 50	5637.6	6165.1	3.50
				Davis	224 45 09	3630.0	3969.7	2.26
Clark's Barn.....	43 54 27.65	69 32 48.66	64 23 49 140 27 22	Kenniston	244 20 59	6078.0	6646.7	3.78
				Edgecombe	320 25 11	6591.0	7207.7	4.09
Luther Davis' House.....	43 51 57.98	69 29 55.46	102 03 13 243 58 20	Kenniston	281 58 23	9358.3	10452.7	5.94
				Davis	64 03 22	10804.4	11815.4	6.71
Barn, north gable.....	43 50 41.81	69 30 01.17	40 22 16 115 14 23	White Island	220 19 27	8440.3	9230.0	5.24
				Kenniston	295 09 37	10193.4	11147.2	6.33
White Spire of church at Round Pond.	43 56 47.51	69 27 24.00	200 56 48 303 33 23	Muscongus	20 57 30	3773.4	4126.5	2.34
				Davis	123 36 40	7595.1	8305.8	4.72
Brown Spire of church at Round Pond.	43 56 48.77	69 27 20.01	199 52 46 304 10 40	Muscongus	19 53 25	3705.8	4052.5	2.30
				Davis	124 13 54	7543.1	8248.9	4.69
Chimney of large unpainted house.	43 56 16.60	69 25 24.30	163 35 36 311 35 03	Muscongus	343 34 55	4667.7	5104.4	2.90
				Davis	131 36 57	4891.6	5349.3	3.04
White House with red roof, chimney	43 56 09.24	69 25 19.51	178 48 47 163 08 36	Johnston	358 48 41	8622.9	9429.8	5.36
				Muscongus	543 07 52	4916.2	5376.2	3.05
Hog Island	43 57 56.30	69 25 12.35	131 28 54 176 20 55	Muscongus	311 28 05	2115.5	2313.4	1.31
				Johnston	356 20 44	5328.2	5826.8	3.31
Greenland Cove, south chimney of White House.	43 59 48.88	69 25 20.47	339 57 42 34 05 59	Davis	159 59 33	10429.0	11404.8	6.48
				Muscongus	214 05 15	2503.8	2738.1	1.56
Our	43 59 08.36	69 24 10.40	346 46 02 74 30 04	Davis	166 47 05	8721.0	9602.6	5.46
				Muscongus	254 28 32	3077.2	3365.2	1.91
Pino	44 00 39.48	69 23 41.49	353 09 11 44 48 04	Davis	173 09 53	11441.9	12512.5	7.11
				Muscongus	224 46 12	5121.2	5600.4	3.18
Cow	43 57 40.51	69 23 11.21	152 23 29 353 16 54	Johnston	332 21 54	6551.2	7164.2	4.07
				Davis	173 16 33	5876.8	6425.7	3.65
Long Island	43 59 06.71	69 23 04.18	134 34 27 356 25 09	Johnston	314 32 47	4481.6	4900.9	2.78
				Davis	176 25 26	8514.2	9310.9	5.29
Hungry	44 00 21.05	69 21 57.80	100 19 54 62 37 00	Johnston	280 17 28	4748.7	5193.0	2.95
				Muscongus	242 33 55	6667.6	7291.5	4.14
Otter	43 55 30.14	69 20 30.03	146 01 24 126 54 25	Johnston	325 57 57	11856.1	12965.5	7.37
				Muscongus	306 50 20	9850.6	10772.4	6.12
Lobster	43 54 40.65	69 22 06.62	158 29 43 142 25 48	Johnston	338 27 23	12207.1	13349.3	7.58
				Muscongus	322 22 50	9387.8	10266.2	5.83
Waldeboro', church spire, No. 1...	44 02 28.30	69 19 28.73	66 12 09 68 52 21	Edgecombe	246 09 43	24076.3	26329.1	14.96
				Johnston	248 54 12	8561.6	9362.6	5.32
Hooper.....	43 55 21.05	69 15 52.91	218 78 36 129 59 18	Turkey Church.....	38 19 40	3307.1	3616.6	2.05
				Caldwell	309 58 16	2587.9	2830.0	1.61
Long White House, chimney in centre.	44 01 04.42	69 19 49.94	86 18 59 63 21 40	Johnston	266 15 04	7535.1	8240.2	4.68
				Muscongus	243 17 06	9810.8	10728.8	6.10
Stahl.....	44 02 44.29	69 22 13.17	50 29 57 355 34 15	Johnston	230 27 42	5610.7	6135.7	3.49
				Hungry	175 34 26	4433.6	4848.4	2.76
Church	44 02 27.19	69 19 29.51	98 15 32 40 19 21	Stahl	278 13 38	3681.2	4025.6	2.29
				Hungry	220 17 38	5104.5	5582.1	3.17
Comery	44 04 42.81	69 21 50.38	7 53 53 323 09 10	Stahl	187 53 37	3602.6	4038.1	2.29
				Church	143 10 48	5229.2	5718.5	3.25
Geel	44 03 42.41	69 22 50.60	330 02 52 219 33 41	Stahl	150 03 24	2070.0	2263.7	1.29
				Comery	39 34 29	2644.2	2844.2	1.50
Kinsel	44 05 05.38	69 23 02.02	358 47 47 293 36 19	Geel	178 47 49	2561.2	2800.8	1.59
				Comery	113 37 09	1739.4	1902.2	1.08
Burns	44 01 35.59	69 21 03.95	143 59 42 232 51 31	Stahl	323 58 54	2621.1	2866.3	1.63
				Church	52 52 37	2637.5	2884.3	1.64
Bremo	44 01 44.88	69 22 18.78	67 34 04 250 52 14	Johnston	247 31 53	4548.6	4974.2	2.83
				Church	70 54 12	3988.4	4301.6	2.48
Red-roofed House, south chimney...	44 02 17.56	69 24 34.50	267 27 55 201 39 43	Church	87 31 27	6796.1	7432.0	4.22
				Kinsel	21 40 47	5572.9	6094.4	3.46

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Muscongus bay, Damariscotta, Kennebec, and Androscoggin Rivers.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	Meters.	Yards.	Miles.
Square Yellow House, chimney....	44 03 00.37	69 20 32.02	77 34 45 306 20 48	Stabl..... Church.....	257 33 35 126 21 31	2305.5 1727.7	2521.2 1889.3	1.43 1.07
One-story White House, chimney..	44 03 58.64	69 20 28.93	81 31 12 334 53 13	Geel..... Church.....	261 29 27 154 53 54	3300.2 3116.7	3707.4 3408.3	2.11 1.94
Waldoboro' Church, cupola.....	44 05 50.92	69 22 11.18	38 49 13 347 34 59	Kinsel..... Comery.....	218 48 38 167 35 13	1803.9 2152.4	1973.7 2353.8	1.12 1.34
Waldoboro', short spire.....	44 05 31.18	69 22 07.32	53 51 17 18 38 18	Kinsel..... Geel.....	223 50 39 198 37 42	1596.8 3640.4	1647.7 3991.0	0.94 2.26
Waldoboro', tall white spire.....	44 05 44.82	69 22 06.50	45 24 59 17 22 24	Kinsel..... Geel.....	225 24 20 197 21 47	1734.6 3957.8	1896.3 4328.1	1.08 2.46
<i>Damariscotta Ri. cr.</i>								
Edgecombe.....	43 57 12.25	69 35 56.91						
Haggett, 1.....	43 59 44.31	69 36 18.62	354 06 35	Edgecombe.....	174 06 50	4717.0	5158.4	2.93
Norwood.....	43 59 52.85	69 33 34.78	85 52 44 32 35 50	Haggett, 1..... Edgecombe.....	265 50 50 212 34 11	3659.7 5881.9	4002.1 6432.3	2.27 3.05
Nichols.....	43 58 18.72	69 33 01.82	165 48 56 62 17 36	Norwood..... Edgecombe.....	345 48 33 242 15 35	2996.4 4409.1	3276.8 4821.7	1.86 2.74
Ariss.....	43 59 14.47	69 32 19.20	125 07 32 28 54 02	Norwood..... Nichols.....	305 06 40 208 53 32	2058.6 1965.5	2251.9 2149.4	1.28 1.22
Hitchcock.....	44 00 45.52	69 31 37.64	18 14 26 58 05 22	Ariss..... Norwood.....	198 13 57 238 04 01	2958.4 3074.1	3235.2 3361.8	1.84 1.91
White.....	44 00 46.95	69 32 58.25	271 24 22 343 02 45	Hitchcock..... Ariss.....	91 25 18 163 03 12	1795.8 3263.7	1963.8 3562.8	1.12 1.85
Harrington's House, chimney.....	43 58 34.22	69 34 22.38	284 55 06 245 38 17	Nichols..... Ariss.....	104 56 02 65 39 43	1858.0 3012.8	2031.8 3294.7	1.15 1.87
Beech.....	43 56 52.85	69 34 02.63	163 14 02 207 05 15	Edgecombe..... Nichols.....	283 12 43 27 05 57	2617.3 2976.5	2862.2 3255.0	1.63 1.85
Small Yellow House, chimney in centre.....	44 00 04.20	69 31 37.65	31 06 48 180 01 07	Ariss..... Hitchcock.....	211 06 19 0 01 07	1794.1 1274.9	1959.8 1394.2	1.11 0.79
School-house, cupola.....	42 02 18.92	69 32 03.15	348 50 24 3 35 55	Hitchcock..... Ariss.....	168 50 41 183 35 44	2937.0 5704.3	3211.9 6238.0	1.83 3.54
Damariscotta, white spire.....	44 01 52.82	69 31 25.65	37 51 00 7 18 58	Norwood..... Hitchcock.....	217 49 30 187 18 50	4628.6 2290.0	5127.3 2590.0	2.91 1.30
Damariscotta, brown spire.....	44 01 58.88	69 31 14.09	46 16 02 13 02 22	White..... Hitchcock.....	226 14 50 193 02 06	3210.6 2323.8	3511.1 2541.3	1.99 1.44
Newcastle, church, brown cupola..	44 02 03.38	69 31 54.84	30 54 44 350 55 19	White..... Hitchcock.....	210 54 00 170 55 31	2749.0 2432.2	3006.2 2659.8	1.71 1.51
<i>Kennebec and Androscoggin Rivers.</i>								
Sprague.....	43 58 30.46	69 53 43.41						
Hodgkin.....	43 58 42.03	69 48 26.07		Sprague.....	267 04 28	7067.9	7729.2	4.39
Brunswick, Congregat'list church spire.....	43 54 37.24	69 57 26.98	214 40 48 237 51 30	Sprague..... Hodgkin.....	34 43 23 57 57 44	8755.1 14220.2	9574.3 15550.8	5.44 8.84
Maxwell.....	44 02 11.55	69 50 14.17	34 21 29 339 40 08	Sprague..... Hodgkin.....	214 19 04 159 41 23	8262.9 6895.0	9036.1 7540.2	5.13 4.28
Hathorn.....	44 01 47.74	69 47 34.28	101 40 28 53 31 06	Maxwell..... Sprague.....	221 38 37 233 26 50	3634.8 10231.4	3974.9 11188.7	2.26 6.36
Bowdoinham, brown spire.....	44 00 30.75	69 53 38.53	1 40 48 295 44 42	Sprague..... Hodgkin.....	181 40 45 115 48 19	3713.7 7715.7	4061.1 8437.6	2.31 4.79
Bowdoinham, white spire.....	44 00 34.19	69 53 36.63	2 16 10 296 35 32	Sprague..... Hodgkin.....	182 16 05 116 39 07	3821.3 7724.5	4178.8 8447.3	2.37 4.80
Buckner.....	43 57 10.73	69 51 14.05	60 22 19 126 28 49	Brunswick, church..... Sprague.....	240 18 00 306 27 05	9571.3 4140.4	10466.7 4527.8	5.95 2.57
Hunter.....	43 55 55.53	69 53 56.68	183 32 14 237 22 07	Sprague..... Buckner.....	3 32 23 57 24 04	4790.7 4305.6	5239.0 4708.4	2.98 2.68
Brunswick, tall tree.....	43 55 07.18	69 53 35.12	178 18 44 162 08 12	Sprague..... Hunter.....	358 18 38 342 07 57	6276.2 1567.4	6863.5 1714.1	3.90 0.97
Foster.....	43 55 12.52	69 55 15.26	274 12 18 232 51 35	Brunswick, tall tree..... Hunter.....	94 13 28 52 52 29	2239.9 2198.6	2449.5 2404.3	1.39 1.37

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Kennebec and Androscoggin Rivers and Boston Harbor.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	Metres.	Yards.	Miles.
House, chimney in centre.....	43 58 58.13	69 51 36.66	225 51 38 351 20 57	Hathorn	45 54 26	7519.7	8223.3	4.67
				Buckner	171 21 13	3352.7	3666.5	2.08
East Telegraph Pole	43 57 04.34	69 48 31.69	73 41 31 166 27 45	Hunter	253 37 46	7550.7	8257.2	4.69
				Maxwell	346 26 34	9752.5	10665.0	6.06
West Telegraph Pole.....	43 56 57.90	69 48 45.08	74 32 20 168 24 51	Hunter	251 28 44	7209.1	7883.7	4.48
				Maxwell	348 23 49	9881.5	10806.1	6.14
<i>Boston Harbor.</i>								
Powderhorn	42 24 02.71	71 01 30.95						
Nantasket	42 18 13.69	70 53 59.10	136 12 09	Powderhorn	316 07 05	14929.1	16326.1	9.28
Corey	42 20 31.38	71 07 41.18	232 22 35	Powderhorn	52 26 44	10688.9	11689.0	6.63
Boston State House	42 21 27.61	71 03 30.00	209 37 50 73 13 51	Powderhorn	29 39 10	5595.9	6021.1	3.42
				Corey	253 11 02	6004.5	6566.3	3.73
Nahant, 1860	42 25 02.83	70 53 57.24	78 54 21 0 11 35	Powderhorn	259 49 15	10538.2	11524.3	6.55
				Nantasket	180 11 34	12622.8	13804.0	7.84
Moon Head, 1860	42 18 20.05	70 59 02.07	162 00 02 271 35 20	Powderhorn	342 07 22	11107.6	12146.9	6.90
				Nantasket	91 38 44	6941.2	7590.7	4.31
South Pettick's Island	42 17 21.83	70 56 30.63	117 22 27 193 50 18	Moon Head, 1860	297 20 45	3903.5	4268.7	2.43
				Nahant, 1860	13 52 01	14652.0	16023.0	9.10
North Pettick's Island, 1860	42 18 04.33	70 55 26.65	143 01 01 95 37 59	Powderhorn	322 56 56	13848.0	15143.7	8.60
				Moon Head, 1860	275 35 34	4957.4	5421.3	3.08
Point Allerton Beacon, 1860	42 18 45.09	70 52 39.19	128 53 44 85 00 02	Powderhorn	308 47 46	15623.7	17085.6	9.71
				Moon Head, 1860	264 55 44	8801.9	9625.5	5.47
Rainsford Island, flag, 1860	42 18 44.92	70 56 46.05	146 24 17 76 10 20	Powderhorn	326 21 05	11774.5	12876.2	7.32
				Moon Head, 1860	256 08 48	3208.1	3508.3	1.99
Outer Brewster, 1860	42 20 27.35	70 52 20.11	165 21 30 117 51 08	Nahant, 1860	345 20 25	8784.9	9606.9	5.46
				Powderhorn	297 44 56	14246.6	15579.6	8.85
Great Brewster, 1860	42 19 59.70	70 53 24.13	175 22 23 123 59 32	Nahant, 1860	355 22 01	9323.0	10261.0	5.83
				Powderhorn	361 54 04	13426.6	14682.9	8.34
Gullop Island, 1860	42 19 35.98	70 56 02.07	60 24 09 312 01 31	Moon Head, 1860	240 22 08	4740.8	5184.4	2.95
				Nantasket	132 02 54	3791.2	4145.9	2.36
Fawn Beacon	42 21 15.00	70 56 11.82	331 33 26 293 41 28	Nantasket	151 34 55	6381.7	6978.9	3.96
				Nahant, 1860	23 42 59	7656.6	8373.0	4.76
South end of Long Island, 1860	42 18 37.61	70 58 15.83	206 26 24 156 01 12	Nahant, 1860	26 29 19	13276.1	14513.4	8.25
				Powderhorn	335 59 01	10979.3	12006.7	6.82
Winthrop Head	42 22 02.09	70 57 44.98	223 01 26 125 46 31	Nahant, 1860	43 03 59	7630.3	8344.2	4.74
				Powderhorn	305 43 29	6369.3	6965.3	3.96
Hospital on Deer Island, cupola	42 21 10.41	70 57 32.09	214 24 05 134 14 03	Nahant, 1860	34 26 30	8693.0	9506.4	5.40
				Powderhorn	314 11 22	7623.7	8337.0	4.74
Hotel on Long Island, cupola	42 19 25.41	70 57 32.33	205 16 43 147 28 36	Nahant, 1860	25 19 08	11514.7	12592.0	7.15
				Powderhorn	327 25 55	10149.5	11099.2	6.31
Thompson's Island, flag, 1860	42 19 05.88	71 00 04.59	280 51 18 167 49 46	Nantasket	100 55 24	8522.8	9320.3	5.30
				Powderhorn	347 48 48	9368.9	10245.5	5.82
Farm School-house, southeast gable, 1860	42 19 03.26	71 00 06.50	280 16 05 168 11 31	Nantasket	100 20 12	8551.0	9351.1	5.31
				Powderhorn	348 10 34	9432.8	10322.0	5.86
House in Fort Warren, west gable	42 19 11.11	70 55 21.30	313 15 02 72 42 43	Nantasket	133 15 57	2584.7	2826.5	1.61
				Moon Head, 1860	252 40 14	5295.0	5790.5	3.29
Calf Island, chimney of Weeks's house	42 20 19.23	70 53 27.93	64 21 38 10 26 41	Moon Head, 1860	244 17 53	8488.1	9282.4	5.27
				Nantasket	190 26 20	3938.1	4306.6	2.45
Weeks's Barn, chimney in middle	42 20 21.50	70 53 31.77	63 40 22 9 01 17	Moon Head, 1860	243 36 40	8439.8	9229.5	5.24
				Nantasket	189 00 59	3992.3	4365.8	2.48
Hull, cupola of Oregon House	42 18 10.15	70 54 26.36	182 59 33 138 15 56	Nahant, 1860	2 59 53	12749.7	13942.6	7.92
				Powderhorn	318 11 10	14585.6	15950.3	9.06
Hull, cupola of Steamboat hotel	42 18 14.27	70 54 47.80	139 21 33 91 46 23	Powderhorn	319 17 01	14175.6	15502.0	8.81
				Moon Head, 1860	271 43 32	5839.7	6386.1	3.63
Kimbal's House, chimney in centre	42 20 17.13	70 53 05.65	121 05 48 17 49 06	Powderhorn	301 00 07	13493.8	14756.5	8.39
				Nantasket	197 43 30	4000.1	4374.4	2.49
Mount Auburn	42 22 08.95	71 08 19.36	248 22 10 343 48 50	Powderhorn	69 26 45	9978.9	10912.6	6.20
				Corey	163 49 16	3134.6	3427.9	1.95
Ten-Hill Farm	42 23 48.51	71 04 54.41	264 35 58 32 07 03	Powderhorn	84 38 15	4673.2	5110.5	2.90
				Corey	212 05 11	7179.6	7851.4	4.46

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Boston Harbor.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	Meters.	Yards.	Miles.
Tufts	42 24 24.87	71 06 52.85	292 29 24 275 16 30	Ten-Hill Farm	112 30 44	2331.4	3205.7	1.82
				Powderhorn	95 20 07	7392.2	8023.9	4.59
Blind Asylum, cupola	42 20 05.05	71 02 11.80	96 10 56 114 28 32	Corey	276 07 14	7523.0	8292.6	4.71
				Mount Auburn	291 24 24	9239.4	10103.9	5.74
South Bay Tripod	42 19 29.09	71 03 25.53	178 24 05 108 12 11	State House	358 24 02	3657.9	4000.1	2.27
				Corey	288 09 19	6159.7	6736.1	3.83
East Boston Reservoir	42 22 50.78	71 01 42.77	112 46 22 190 24 17	Ten-Hill Farm	292 44 17	4604.1	5034.9	2.86
				Powderhorn	10 24 29	2256.2	2467.3	1.40
South Boston Point	42 20 11.03	71 01 12.38	126 53 19 82 16 40	State House	306 51 46	3937.1	4305.5	2.45
				Blind Asylum	262 16 00	1372.5	1500.9	0.85
Governor's Island, 2	42 21 07.11	71 00 21.79	52 45 09 163 43 43	Blind Asylum	232 43 55	3163.3	3459.3	1.97
				Powderhorn	343 42 56	5643.9	6172.0	3.51
Lincoln's Wharf	42 21 55.75	71 02 37.12	350 22 33 201 07 26	Blind Asylum	170 22 50	3464.1	3788.2	2.15
				Powderhorn	21 08 11	4199.3	4592.3	2.61
Eastern Avenue Wharf	42 21 48.12	71 02 35.12	350 28 09 199 27 38	Blind Asylum	170 28 25	3221.7	3526.4	2.00
				Powderhorn	19 28 21	4404.3	4816.4	2.74
Long Wharf	42 21 34.46	71 02 32.49	350 15 34 197 06 02	Blind Asylum	170 15 48	2799.1	3061.1	1.74
				Powderhorn	17 06 43	4785.6	5233.4	2.97
Foster's Wharf	42 21 19.17	71 02 40.30	344 04 31 276 40 42	Blind Asylum	164 04 50	2778.2	2990.8	1.48
				Governor's Island, 2	96 42 15	3191.4	3490.0	1.98
Loring's Machine Shop Wharf	42 20 29.61	71 01 41.64	42 19 53 237 39 13	Blind Asylum	222 19 33	1025.2	1121.1	0.64
				Governor's Island, 2	57 40 07	2163.1	2365.5	1.34
South Boston Reservoir	42 19 56.52	71 02 25.48	188 52 36 229 58 49	East Boston Reservoir	8 53 01	5441.0	5950.1	3.38
				Blind Asylum	49 58 58	409.0	447.2	0.25
Boston Neck, dark spire	42 20 24.74	71 04 04.19	332 43 16 92 23 06	South Bay Tripod	152 43 42	1931.4	2112.1	1.20
				Corey	272 20 49	4970.8	5435.9	3.09
Catholic Cathedral, statue	42 20 10.68	71 04 04.10	273 51 20 325 27 26	Blind Asylum	93 52 30	2576.3	2817.4	1.60
				South Bay Tripod	145 27 52	1557.4	1703.1	0.97
Berkley Street, yellow spire	42 20 42.15	71 03 54.37	343 40 04 86 21 42	South Bay Tripod	163 40 23	2348.6	2568.3	1.46
				Corey	266 19 09	5201.7	5688.5	3.24
Roxbury Oil Works	42 19 53.41	71 03 34.09	259 11 57 345 20 57	Blind Asylum	79 12 52	1917.5	2096.9	1.19
				South Bay Tripod	165 21 03	775.3	847.8	0.48
Machine Shop, tall chimney on ridge pole	42 20 26.61	71 03 32.04	288 37 07 350 49 36	Blind Asylum	108 38 05	2083.1	2278.0	1.29
				South Bay Tripod	170 49 44	1797.5	1965.7	1.11
Gas Works, ventilator	42 20 48.29	71 03 06.13	10 18 09 261 12 19	South Bay Tripod	190 17 56	2483.5	2715.9	1.54
				Governor's Island, 2	81 14 10	3805.3	4161.4	2.37
South Boston, cross on dark spire, with turrets	42 20 29.88	71 03 03.39	302 58 33 15 07 05	Blind Asylum	122 59 08	1407.5	1539.2	0.87
				South Bay Tripod	195 06 50	1942.8	2124.6	1.21
Fulton Wire Works, south chimney	42 20 06.04	71 03 08.51	271 21 08 18 52 14	Blind Asylum	91 21 46	1298.3	1419.8	0.80
				South Bay Tripod	198 52 03	1204.6	1317.3	0.75
Lawrence School, cupola	42 20 26.79	71 02 51.83	23 26 04 250 03 54	South Bay Tripod	203 25 41	1939.9	2121.4	1.20
				Governor's Island, 2	70 05 35	3632.1	3993.8	2.27
Flagstaff, corner of Dorchester street and turnpike	42 19 45.61	71 03 05.44	42 03 48 162 38 15	South Bay Tripod	222 03 34	686.2	750.4	0.42
				Corey	282 35 09	6467.9	7073.1	4.02
Suffolk Cordage Factory, ball	42 19 36.04	71 03 59.20	249 59 20 285 31 59	Blind Asylum	70 00 32	2616.2	2861.0	1.63
				South Bay Tripod	105 32 22	800.1	875.0	0.50
Prentice's Coal Wharf, post	42 21 06.77	71 02 50.53	269 48 25 335 02 00	Governor's Island, 2	89 50 05	3403.9	3722.4	2.12
				Blind Asylum	155 02 26	2100.7	2297.3	1.31
Railroad Tripod	42 20 50.38	71 02 36.77	296 55 23 260 29 56	Loring's Wharf	116 56 00	1415.1	1547.5	0.88
				Governor's Island, 2	89 31 27	3131.7	3424.8	1.95
Sailors' Home, cupola	42 21 17.12	71 02 47.34	275 16 48 339 54 10	Governor's Island, 2	95 18 26	3345.0	3658.0	2.08
				Blind Asylum	159 54 34	2367.8	2579.3	1.47
Reylston School, cupola	42 21 19.53	71 02 47.98	276 30 57 340 10 54	Governor's Island, 2	96 32 35	3367.1	3682.2	2.09
				Blind Asylum	169 11 18	2442.6	2671.1	1.52
Fort Hill Wharf, post	42 21 13.77	71 02 44.11	273 35 33 340 46 01	Governor's Island, 2	93 37 09	3263.4	3568.7	2.03
				Blind Asylum	160 46 23	2245.6	2455.7	1.40
Central Wharf, cupola	42 21 30.56	71 02 44.15	282 30 19 344 19 16	Governor's Island, 2	102 31 55	3337.0	3649.2	2.07
				Blind Asylum	164 19 58	2740.3	2996.7	1.70
India Wharf, cupola	42 21 27.11	71 02 38.65	281 07 48 346 21 09	Governor's Island, 2	101 09 20	3192.0	3490.7	1.98
				Blind Asylum	166 21 27	2605.5	2849.3	1.62
India Wharf, post	42 21 26.05	71 02 38.03	280 36 02 346 29 18	Governor's Island, 2	100 37 34	3171.9	3468.7	1.97
				Blind Asylum	166 29 36	2570.4	2810.9	1.60

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Boston Harbor.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	Meters.	Yards.	Miles.
Lewis's Wharf, cupola	42 21 45.45	71 02 38.96	290 38 05 348 39 08	Governor's Island, 2	110 39 37 168 39 26	3354.1 3159.5	3638.0 3455.1	2.09 1.96
James & Pope's Timber Dock, post.	42 20 30.52	71 02 18.63	271 53 24 348 45 15	Loring's Wharf	91 53 49	847.0	926.2	0.52
				Blind Asylum	168 45 20	601.3	676.3	0.50
Cunard Wharf, pole	42 21 48.36	71 02 07.99	337 01 57 297 38 42	South Boston Point	157 02 34	3262.0	3567.2	2.03
				Governor's Island, 2	117 39 54	2743.2	2999.9	1.70
Grand Junction Wharf, shears	42 21 45.41	71 02 01.87	297 16 57 4 11 49	Governor's Island, 2	117 18 04	2576.9	2818.0	1.60
				Blind Asylum	184 11 42	3105.0	3395.6	1.93
Bay State Steam Engine Works, wharf post.	42 21 43.54	71 01 48.63	299 28 43 9 53 56	Governor's Island, 2	119 29 41	2282.8	2496.4	1.42
				Blind Asylum	189 53 40	3084.6	3373.2	1.92
Adams school, flagstaff	42 21 55.87	71 01 38.01	310 46 11 12 44 40	Governor's Island, 2	130 47 02	2303.2	2518.7	1.43
				Blind Asylum	192 44 17	3505.6	3833.6	2.18
Dry Dock, post	42 21 42.78	71 01 33.75	303 44 59 16 06 44	Governor's Island, 2	123 45 47	1920.3	2165.6	1.23
				Blind Asylum	196 06 18	3138.7	3432.4	1.95
Ship Yard, wharf post	42 21 48.14	71 01 20.53	313 16 35 20 14 01	Governor's Island, 2	133 17 14	1846.2	2019.0	1.15
				Blind Asylum	200 14 36	3390.3	3707.5	2.11
Bird Island Beacon	42 21 16.07	71 00 54.89	290 02 26 38 46 43	Governor's Island, 2	110 02 48	806.3	881.8	0.50
				Blind Asylum	218 45 51	2807.1	3062.8	1.74
Fort Independence, flagstaff	42 20 16.92	71 00 23.85	80 43 12 181 44 10	South Boston Point	260 42 39	1125.6	1230.9	0.70
				Governor's Island, 2	1 44 11	1549.3	1694.3	0.96
Hog Island Tripod	42 23 28.20	71 00 18.62	60 45 58 122 46 32	East Boston Reservoir	240 44 57	2353.1	2584.2	1.47
				Powderhorn	302 45 43	1907.2	2151.3	1.22
Chelsea, cross on dark spire	42 23 38.49	71 01 33.63	101 07 08 184 40 09	Tufts	281 03 33	7438.2	8134.2	4.62
				Powderhorn	4 40 11	749.7	819.8	0.46
Chelsea, white spire, (martin-hole windows.)	42 23 22.58	71 01 58.85	101 17 06 207 15 28	Ten-Hill Farm	281 15 08	4093.8	4476.9	2.54
				Powderhorn	27 15 47	1393.0	1523.4	0.86
Chelsea, white spire, with clock	42 23 25.45	71 01 57.12	100 00 33 207 26 10	Ten-Hill Farm	279 58 23	4116.9	4502.1	2.56
				Powderhorn	27 26 28	1298.7	1420.2	0.81
Chelsea, white spire (three tiers windows.)	42 23 34.22	71 01 55.06	96 09 01 212 05 58	Ten-Hill Farm	276 07 00	4125.0	4511.0	2.56
				Powderhorn	32 05 14	1037.7	1134.8	0.64
Chelsea, tall dark spire	42 23 28.59	71 01 55.83	104 22 08 352 07 25	Tufts	284 18 48	7010.4	7666.3	4.36
				East Boston Reservoir	172 07 30	1177.9	1288.1	0.73
Chelsea, brown tower	42 23 27.01	71 01 25.34	25 36 49 173 21 25	East Boston Reservoir	205 36 33	1229.7	1355.7	0.77
				Powderhorn	353 21 21	1108.9	1212.6	0.69
East Boston, dark spire of brick church.	42 22 24.79	71 02 00.85	119 02 48 192 44 40	Tufts	298 50 31	7636.8	8351.3	4.75
				Powderhorn	12 45 00	3097.7	3387.5	1.92
East Boston, dark spire of granite church.	42 22 14.07	71 02 07.38	121 44 42 193 57 20	Tufts	301 41 30	7675.3	8393.5	4.77
				Powderhorn	13 57 45	3453.8	3777.0	2.15
Chimney of Gas Works, in north end of Boston.	42 21 59.92	71 03 07.35	130 56 53 210 11 24	Tufts	310 54 21	6826.3	7465.0	4.24
				Powderhorn	30 12 29	4383.3	4793.4	2.73
Charlestown, cross on brick church.	42 22 19.89	71 03 27.56	220 02 42 247 07 27	Powderhorn	40 04 01	4144.3	4532.1	2.57
				East Boston Reservoir	67 08 34	2458.7	2688.8	1.53
Bunker Hill, cross on Catholic church.	42 22 51.36	71 03 39.65	123 09 30 233 11 42	Tufts	303 07 20	5276.7	5770.4	3.28
				Powderhorn	53 13 09	3675.3	4019.2	2.28
Chimney of Gas Works, near Mal- den bridge.	42 23 16.77	71 04 08.65	133 05 56 248 31 38	Ten-Hill Farm	313 05 25	1433.3	1567.4	0.89
				Powderhorn	68 33 24	3674.9	4037.5	2.41
Marine Hospital, cupola	42 23 19.23	71 02 22.64	104 35 55 221 22 59	Ten-Hill Farm	284 34 13	3580.4	3922.0	2.23
				Powderhorn	41 23 34	1787.9	1955.2	1.11
Edgeworth Mills, round chimney ..	42 24 59.41	71 04 09.64	295 41 43 24 58 58	Powderhorn	115 43 30	4032.0	4409.3	2.50
				Ten-Hill Farm	204 58 28	2413.1	2638.9	1.50
New England Glass Company, chimney.	42 22 19.37	71 04 19.26	137 47 52 230 21 01	Tufts	317 46 08	5227.9	5717.0	3.25
				Powderhorn	50 22 54	4998.3	5466.0	3.10
Church at head of Miller's river	42 22 42.08	71 05 27.77	37 08 22 75 25 15	Corey	217 06 52	5057.7	5530.9	3.14
				Mount Auburn	355 23 19	4056.4	4436.0	2.52
Somerville, red church on hill	42 23 10.00	71 05 31.44	141 08 17 253 30 16	Tufts	321 07 20	2966.7	3244.3	1.84
				Powderhorn	73 32 58	5735.1	6271.8	3.56
West chimney of Grain Mill, near turnpike.	42 24 03.20	71 05 30.64	270 08 01 238 40 36	Powderhorn	90 10 43	5480.9	5993.8	3.41
				Ten-Hill Farm	118 41 09	944.4	1032.8	0.59
Cupola of Brick Factory, near Mystic river.	42 24 30.79	71 05 06.06	279 58 04 85 43 49	Powderhorn	100 00 29	4994.2	5461.5	3.10
				Tufts	265 42 37	2448.5	2677.6	1.52
Tall chimney on north side of Mystic river.	42 24 34.20	71 05 00.92	281 25 07 353 58 09	Powderhorn	101 27 29	4898.3	5356.7	3.04
				Ten-Hill Farm	173 58 13	1417.5	1550.1	0.88

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Boston Harbor, and Hope Bay, Rhode Island.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ' "	° ' "	° ' "		° ' "	Metres.	Yards.	Miles.
Tall square chimney in Medford, near bridge.	42 24 50.19	71 06 10.59	282 52 39 51 02 41	Powderhorn	102 55 42	6554.3	7175.1	4.07
				Tufts	231 02 12	1242.6	1358.8	0.77
Malden, yellow spire	42 25 36.79	71 03 40.42	314 25 33 63 15 00	Powderhorn	134 27 00	4145.4	4533.3	2.58
				Tufts	243 12 50	4926.9	5387.9	3.06
Navy Yard, chimney	42 22 28.05	71 02 48.12	122 47 40 211 08 16	Tufts	302 45 15	6657.0	7270.8	4.13
				Powderhorn	31 09 08	3412.3	3731.6	2.12
Boston Jail, cupola	42 21 41.26	71 03 53.39	140 53 58 216 43 48	Tufts	320 51 57	6505.9	7114.6	4.04
				Powderhorn	36 45 24	5446.2	5935.8	3.38
State Prison, cupola	42 22 26.25	71 03 47.80	130 52 08 226 25 48	Tufts	310 50 03	5595.0	6118.5	3.47
				Powderhorn	46 27 20	4319.1	4723.3	2.68
East Cambridge Court-house, cupola	42 22 09.99	71 04 27.45	89 40 37 229 14 16	Mount Auburn	209 38 01	5305.9	5802.4	3.30
				Powderhorn	49 16 15	5328.4	5827.0	3.31
Cambridgeport, dome of observatory	42 21 17.07	71 06 14.83	54 30 39 119 29 20	Corey	224 29 41	2427.5	2654.6	1.51
				Mount Auburn	299 18 56	3268.3	3574.1	2.03
Cambridgeport Redoubt, flagstaff ..	42 21 21.80	71 05 56.19	57 02 18 113 54 54	Corey	237 01 07	2864.0	3132.0	1.78
				Mount Auburn	293 53 18	3583.0	3918.3	2.23
Cambridgeport, flagstaff near engine-house.	42 21 43.60	71 04 54.61	59 42 37 151 29 05	Corey	239 40 45	4415.3	4828.5	2.74
				Tufts	331 27 45	5663.2	6193.1	3.52
West Boston Bridge, pole on draw ..	42 21 39.51	71 04 05.07	66 59 41 98 53 53	Corey	246 57 15	5373.6	5876.4	3.34
				Mount Auburn	278 51 07	5688.4	6193.4	3.66
Carpet Cleaning Factory, ventilator	42 21 14.63	71 04 18.89	73 56 24 106 57 49	Corey	253 54 08	4818.0	5268.8	2.99
				Mount Auburn	286 55 07	5751.7	6289.9	3.58
Milldam, chimney of yellow house.	42 20 54.23	71 05 30.65	76 44 09 163 52 14	Corey	256 42 41	3661.5	3956.7	1.91
				Tufts	343 51 19	6765.3	7388.3	4.20
Milldam Regatta House, flagstaff ..	42 21 02.90	71 04 57.98	113 52 36 73 25 17	Mount Auburn	293 50 20	5038.4	5509.9	3.13
				Tufts	255 23 27	3659.7	4020.8	2.40
North Brighton, dark spire	42 21 11.69	71 07 51.33	349 25 10 160 03 00	Corey	169 25 17	1260.6	1378.6	0.78
				Mount Auburn	349 02 41	1879.7	2055.6	1.17
Cambridge Gas Works, chimney ..	42 22 22.37	71 07 15.77	127 53 43 9 38 43	Tufts	7 53 58	2815.8	3072.8	1.78
				Corey	189 38 26	3173.2	3478.2	2.16
Planing Mill, chimney	42 22 14.11	71 06 56.21	17 59 44 85 13 36	Corey	197 56 14	3332.5	3644.3	2.07
				Mount Auburn	265 12 40	1900.1	2087.8	1.19
Varnish Factory, chimney	42 21 47.55	71 06 45.31	28 33 14 107 04 10	Corey	208 32 36	2675.3	2925.6	1.66
				Mount Auburn	287 03 07	2250.8	2461.4	1.40
Riverside Press, chimney	42 21 44.04	71 06 36.04	33 37 56 108 01 24	Corey	213 37 12	2692.1	2944.0	1.67
				Mount Auburn	288 00 14	2485.8	2718.4	1.55
Charles River Tripod	42 21 07.42	71 06 39.27	129 39 49 177 04 53	Mount Auburn	309 38 42	2974.9	3253.3	1.85
				Tufts	357 04 46	6099.7	6670.4	3.79
Chimney of small red house on marsh.	42 24 43.91	71 05 46.70	68 46 26 325 01 30	Tufts	218 45 41	1632.5	1774.3	1.01
				Ten-Hill Farm	145 02 05	2086.1	2281.3	1.30
<i>Hope Bay, Rhode Island.</i>								
QUAKER	41 34 55.14	71 14 57.37						
Mount Hope	41 40 23.95	71 14 05.17	6 47 20	Quaker	186 46 45	10213.9	11169.6	6.35
Slade	41 43 39.04	71 09 48.02	44 40 11	Mount Hope	294 37 20	8459.4	9251.0	5.26
Blackbeard	41 40 26.68	71 10 37.76	89 00 21	Mount Hope	268 58 03	4797.5	5246.4	2.98
Mattapoiset	41 42 38.29	71 12 30.70	27 47 44 337 14 25	Mount Hope	207 46 41	4685.0	5123.4	2.91
				Blackbeard	147 15 39	4827.2	5278.9	3.00
Toweset	41 41 57.04	71 14 12.70	356 31 42 299 15 57	Mount Hope	176 31 47	2877.5	3146.8	1.79
				Blackbeard	119 18 20	5698.3	6231.5	3.54
Anthony	41 38 44.17	71 12 57.59	153 04 36	Mount Hope	333 03 50	3452.3	3775.3	2.15
Bristol, Methodist church spire	41 40 13.20	71 16 10.88	263 29 08 359 09 00	Mount Hope	83 30 32	2668.3	2918.0	1.66
				Quaker	170 09 49	9957.6	10880.3	6.19
Fall River, 2	41 42 37.56	71 08 24.29	62 25 25 134 25 48	Mount Hope	242 21 38	8894.5	9726.7	5.53
				Slade	314 24 52	2709.9	2963.4	1.68
Somerset	41 44 05.43	71 09 45.42	325 19 12 41 20 07	Fall River, 2	145 20 06	3295.8	3604.1	2.05
				Mount Hope	221 17 15	9096.1	9947.2	5.65
Somerset, spire	41 44 09.49	71 09 45.77	326 24 26 40 46 51	Fall River, 2	146 25 20	3404.1	3722.6	2.12
				Mount Hope	220 43 58	9185.2	10044.7	5.71
Fall River, derrick	41 42 17.14	71 09 35.65	60 45 44 176 07 56	Mount Hope	240 42 45	7143.8	7812.3	4.44
				Somerset	356 07 50	3348.0	3661.2	2.08

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Hope Bay, Rhode Island.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	<i>Metres.</i>	<i>Yards.</i>	<i>Miles.</i>
Durfee, cupola.....	41 42 34.20	71 08 43.72	61 38 00 143 23 40	Mount Hope..... Slade.....	241 34 26 323 22 57	8449.1 2492.2	9239.7 2725.4	5.25 1.55
Dodge's Stable, turret.....	41 40 54.15	71 09 19.16	79 54 48 188 02 57	Mount Hope..... Slade.....	259 52 18 8 03 18	5399.3 5137.5	5806.1 5618.2	3.30 3.19
Fall River, spire.....	41 42 04.69	71 08 53.03	38 27 36 101 42 23	Blackbeard..... Mattapoiset.....	218 26 27 281 39 59	3860.7 5117.0	4222.0 5595.8	2.40 3.18
Fall River, tower.....	41 41 58.70	71 09 04.32	67 14 10 161 55 49	Mount Hope..... Slade.....	247 10 50 341 55 20	7545.8 3256.2	8251.8 3560.9	4.69 2.02
West.....	41 38 42.24	71 15 20.97	209 11 28 268 57 26	Mount Hope..... Anthony.....	29 12 18 88 59 01	3594.3 3318.2	3930.6 3628.7	2.23 2.06
Papoose Squaw, 2.....	41 39 13.02	71 17 41.42	246 21 15 286 16 29	Mount Hope..... West.....	66 23 39 106 18 02	5459.8 5385.5	5970.7 3702.3	3.39 2.10
Hog Island, 2.....	41 38 32.30	71 16 29.75	192 51 49 225 43 48	Papoose Squaw, 2..... Mount Hope.....	302 51 01 45 45 24	1973.9 4069.9	2158.6 5106.8	1.23 2.90
Globe Village, chimney.....	41 41 15.09	71 10 02.75	74 18 07 126 53 55	Mount Hope..... Mattapoiset.....	254 15 26 306 52 17	5823.9 4276.6	6368.9 4676.7	3.62 2.66
Spar Island.....	41 41 15.21	71 12 53.63	46 17 34 125 13 45	Mount Hope..... Toweset.....	226 16 46 305 12 52	2228.7 2237.8	2502.8 2447.2	1.42 1.39

Section II.—Connecticut River.

Williams.....	41 21 16.61	72 30 49.11						
Nickerson.....	41 23 51.55	72 19 19.01	72 27 59	Williams.....	252 20 23	16731.5	18297.0	10.40
Malicah.....	41 20 32.83	72 19 48.68	186 24 51 95 05 19	Nickerson..... Williams.....	6 25 11 274 58 03	6168.3 15410.9	6745.5 16852.9	3.83 9.58
Brown's Hill.....	41 09 08.91	72 17 15.87						
Beacon Hill.....	41 17 32.27	72 23 48.34	208 07 47 329 28 46	Nickerson..... Brown's Hill.....	28 10 41 149 33 05	13269.2 18017.4	14510.8 19703.3	8.24 11.19
Lay's Hill, 2.....	41 16 55.85	72 17 44.49	97 32 01 357 37 29	Beacon Hill..... Brown's Hill.....	277 27 59 177 37 46	8609.1 14415.8	9414.7 15764.6	5.35 8.96
Ferry Hill, 2.....	41 18 55.56	72 21 36.47	304 01 10 50 04 00	Lay's Hill, 2..... Beacon Hill.....	124 03 45 230 02 33	6596.8 4007.6	7214.0 4382.6	4.10 2.49
Essex, 2.....	41 20 31.00	72 23 28.58	223 07 33 318 27 50	Nickerson..... Ferry Hill, 2.....	43 10 16 138 20 04	8479.3 3932.0	9272.7 4299.9	5.27 2.44
Lord.....	41 21 22.56	72 20 26.88	67 12 49 132 40 22	Essex, 2..... Malicah.....	247 10 49 152 40 47	4581.3 2115.5	5009.9 2115.5	2.85 1.20
Book Hill.....	41 22 04.21	72 24 26.87	245 07 52 394 45 44	Nickerson..... Essex, 2.....	65 11 16 154 46 23	7881.6 3178.5	8619.1 3475.9	4.90 1.97
Honey Hill.....	41 23 47.52	72 21 13.85	267 19 49 341 45 01	Nickerson..... Malicah.....	87 20 56 161 45 57	2670.3 6323.0	2920.1 6914.7	1.66 3.93
Doane.....	41 22 24.86	72 24 27.08	298 04 39 240 23 07	Malicah..... Honey Hill.....	118 07 43 60 25 15	7335.1 5162.6	8021.5 5645.6	4.56 3.21
Cedar.....	41 22 39.65	72 23 19.54	3 01 48 308 34 46	Essex, 2..... Malicah.....	183 01 42 128 37 05	3974.2 6270.2	4346.1 6856.9	2.47 3.90
Ely, 2.....	41 21 49.16	72 22 06.67	38 17 57 132 37 04	Essex, 2..... Cedar.....	218 17 03 312 36 16	3072.0 2300.6	3359.5 2515.9	1.91 1.43
Ely, 3.....	41 21 50.65	72 22 04.21	38 35 55 353 10 53	Essex, 2..... Ferry Hill, 2.....	218 34 59 173 11 12	3143.5 5439.2	3437.6 5948.2	1.96 3.38
Selden.....	41 24 17.93	72 23 42.25	350 07 27 16 37 34	Cedar..... Doane.....	170 07 42 196 37 05	3077.2 3640.0	3365.2 3980.6	1.91 2.26
Cone.....	41 24 36.46	72 26 32.31	281 30 23 278 13 09	Honey Hill..... Selden.....	101 33 53 98 14 52	7548.8 3990.4	8255.1 4363.7	4.69 2.48
Wahginnicut.....	41 23 41.29	72 25 25.43	230 05 44 137 36 56	Doane..... Cone.....	150 06 23 317 36 12	2719.4 2304.0	2973.9 2519.6	1.69 1.43
Brooks.....	41 25 21.95	72 25 22.50	49 07 17 1 15 17	Cone..... Wahginnicut.....	229 06 31 181 15 15	2144.1 3105.9	2344.7 3396.5	1.33 1.93
Noyes.....	41 18 57.26	72 20 12.63	122 24 49 88 27 08	Essex, 2..... Ferry Hill, 2.....	302 22 40 268 26 13	5395.9 1950.6	5900.7 2133.2	3.35 1.21

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section II.—Connecticut River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	<i>Metres.</i>	<i>Yards.</i>	<i>Miles.</i>
Gelston	41 26 55.29	72 26 11.00	338 38 28 6 35 32	Brooks	158 39 00	3091.6	3380.9	1.92
				Cone	186 35 18	4311.3	4714.7	2.68
Holt	41 25 39.02	72 27 09.41	292 34 54 281 58 04	Honey Hill	112 38 49	8944.4	9781.3	5.56
				Brooks	101 59 15	2537.4	2774.8	1.58
Gravel Bluff	41 19 18.11	72 20 45.28	310 13 53 39 42 39	Noyes	130 14 15	994.7	1087.7	0.62
				Ferry Hill, 2	239 42 06	1378.7	1507.7	0.86
Bald Hill	41 27 40.82	72 24 46.35	325 32 55 23 23 54	Honey Hill	145 35 16	8725.3	9541.7	5.42
				Cone	263 22 44	6196.2	6776.0	3.85
Mount Parnassus	41 28 01.34	72 24 20.03	317 46 03 0 49 33	Nickerson	137 49 22	10403.4	11375.7	6.46
				Book Hill	180 49 29	11017.7	12048.5	6.85
Higgins' Wharf	41 19 28.67	72 20 12.86	62 17 26 149 25 19	Ferry Hill, 2	242 16 31	2196.2	2401.7	1.36
				Ely, 3	329 24 05	5587.4	6093.4	3.16
Pilgrim	41 19 47.27	72 20 06.91	52 33 44 106 01 11	Ferry Hill, 2	232 32 45	2623.1	2868.6	1.63
				Essex, 2	286 01 58	4878.8	5335.3	3.03
Ayer	41 19 53.59	72 21 17.85	318 51 55 239 42 16	Noyes	138 52 38	2905.9	3151.6	1.43
				Malicah	59 43 15	2400.5	2625.1	1.49
Pine Island	41 20 23.82	72 20 30.41	89 26 20 93 04 23	Ferry Hill, 2	206 25 36	3125.9	3418.3	1.94
				Essex, 2	273 02 25	4147.9	4536.0	2.58
Hayden's Point	41 20 34.89	72 22 17.99	186 32 56 187 48 02	Ely, 2	6 33 03	2306.1	2521.9	1.43
				Ely, 3	7 48 11	2358.8	2579.5	1.46
Beckwith's Point	41 21 10.19	72 21 02.51	10 45 48 70 24 54	Ferry Hill, 2	196 45 26	4227.3	4622.9	2.63
				Essex, 2	250 23 17	3604.5	3941.7	2.24
Essex, Congregationalist church	41 21 07.64	72 23 13.72	282 40 15 227 08 42	Malicah	102 42 30	4885.5	5342.6	3.04
				Nickerson	47 11 17	7436.5	8132.3	4.62
Essex, Baptist church	41 21 15.93	72 23 13.05	285 36 39 228 32 40	Malicah	103 38 54	4932.8	5394.4	3.07
				Nickerson	48 35 15	7253.2	7931.9	4.51
Essex, Episcopal church spire	41 21 08.76	72 23 11.91	230 34 44 283 10 48	Ely, 2	50 35 27	1962.9	2146.6	1.22
				Malicah	103 13 02	4852.4	5306.4	3.02
Williams's Dock	41 21 35.55	72 23 08.09	213 05 36 273 17 00	Honey Hill	33 06 52	4859.5	5314.2	3.02
				Lord	93 18 46	3752.7	4103.9	2.33
Hamburg Cove	41 22 34.34	72 22 00.49	313 00 11 95 06 08	Lord	133 01 13	2974.9	3253.3	1.85
				Cedar	275 05 16	1843.9	2016.5	1.15
Joshua Rock	41 22 49.52	72 22 17.29	21 11 57 78 07 41	Essex, 2	201 11 10	4582.6	5011.3	2.85
				Cedar	258 07 00	1477.7	1616.0	0.92
Buckingham	41 22 54.03	72 23 27.40	241 58 54 172 24 23	Honey Hill	62 00 22	3513.7	3842.4	2.18
				Selden	352 24 13	2611.0	2855.3	1.62
Selden's Neck	41 23 40.73	72 24 34.22	355 56 39 90 49 28	Doane	175 56 44	2346.4	2565.9	1.46
				Wahginnicut	270 48 54	1189.6	1300.9	0.74
Brockway	41 23 21.32	72 22 58.23	251 33 15 7 38 52	Honey Hill	71 34 24	2555.6	2794.7	1.59
				Essex, 2	187 38 32	5301.2	5797.2	3.30
Joe Post's Light-house	41 23 18.05	72 24 44.79	127 12 39 167 05 52	Wahginnicut	307 12 12	1183.2	1296.1	0.74
				Brooks	347 05 27	3920.8	4287.7	2.44
Grassy Hill	41 23 43.27	72 16 55.92	57 00 38 94 24 16	Essex, 2	236 56 19	10882.5	11900.7	6.76
				Nickerson	274 22 41	3333.5	3645.4	2.07
Locust	41 24 59.92	72 26 57.25	166 49 47 252 49 41	Holt	346 49 39	1238.6	1354.5	0.77
				Brooks	72 50 44	2302.6	2518.0	1.43
East Haddam, Episcopal church spire	41 27 35.42	72 27 13.25	310 04 57 358 34 33	Honey Hill	130 08 55	10910.7	11931.6	6.78
				Holt	178 34 36	3591.9	3928.0	2.23
East Haddam, Congregationalist church spire	41 28 47.02	72 26 28.49	310 44 41 225 17 23	Bald Hill	130 45 49	3128.1	3420.8	1.94
				Mount Parnassus	115 18 48	3296.6	3605.0	2.05
Deep River, spire	41 23 09.81	72 25 44.29	157 21 03 307 41 52	Cone	337 20 31	2895.9	3166.8	1.80
				Doane	127 42 43	2267.3	2479.5	1.41
Chester, church steeple	41 24 02.32	72 26 54.69	263 49 57 273 16 12	Selden	83 52 04	4495.2	4915.8	2.79
				Honey Hill	93 19 57	7929.8	8671.8	4.93
Quarry	41 24 24.42	72 24 56.62	26 42 18 161 17 30	Wahginnicut	206 41 59	1489.3	1628.7	0.92
				Brooks	341 17 13	1873.7	2049.0	1.17
Hadlyme, cupola	41 25 51.29	72 24 00.86	351 28 08 64 29 03	Selden	171 28 20	2912.0	3184.5	1.81
				Brooks	244 28 09	2100.4	2296.9	1.31
Wahginnicut House, flag	41 23 40.70	72 25 18.68	178 22 19 242 50 37	Brooks	358 22 16	3124.5	3416.8	1.94
				Selden	62 51 41	2516.8	2752.3	1.56
Horton's Point Light-house	41 05 04.20	72 26 25.05	188 58 41 239 26 32	Beacon Hill	9 00 24	2362.1	25548.1	14.52
				Brown's Hill	59 32 33	14862.7	16260.0	9.24

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section II.—Hudson River—Yonkers to Tarrytown, and Hudson to Troy.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	Metres.	Yards.	Miles.
Kieckout	41 05 18.18	73 50 52.14						
Piermont, engine-house	41 02 27.18	73 54 31.93	227 50 55	Kieckout	47 53 39	7862.7	8598.5	4.89
Piermont, pier	41 02 31.69	73 53 29.06	230 20 11	Kieckout	40 22 14	6738.9	7369.4	4.19
Smith, 2	41 04 40.95	73 54 43.72	279 19 25 356 10 56	Engine-house	79 22 17 176 11 04	6212.0 4135.4	6793.3 4522.3	3.86 2.57
Van Tassel	41 03 18.25	73 51 53.32	122 40 50 66 57 59	Smith, 2	302 38 58 246 56 15	4725.6 4024.9	5167.8 4401.6	2.94 2.50
Irvington, pier	41 02 23.43	76 52 08.30	191 41 36 91 58 34	Van Tassel	11 41 46 271 57 00	1726.7 3356.0	1888.2 3670.1	1.07 2.09
Upper Dobbs's Ferry	41 01 06.09	73 52 26.56	190 08 04 130 30 10	Irvington, pier	10 08 16 310 28 48	2422.9 3850.1	2649.6 4210.3	1.51 2.39
Meadow Point	41 01 03.97	73 53 49.39	158 50 04 223 55 32	Engine-house	338 49 36 43 56 38	2751.2 3403.1	3008.6 3721.5	1.71 2.12
Duer	40 59 50.92	73 53 50.46	180 38 29 230 10 49	Meadow Point	0 38 30 40 11 44	2255.7 3038.3	2466.7 3322.6	1.40 1.89
Hastings	40 59 29.85	73 52 50.25	114 41 19 154 32 59	Upper Dobbs's Ferry				
N. Boat-house	41 00 09.69	73 52 42.78	69 48 02 8 05 41	Duer	294 40 39 334 32 20	1548.5 3214.3	1693.4 3515.1	0.96 2.00
Rockwell	40 59 34.22	73 53 51.17	235 36 07 275 23 53	Hastings	349 47 18 188 05 36	1685.5 1241.1	1843.2 1357.2	1.05 0.77
Baumer's Pier	40 58 12.82	73 53 06.47	157 24 27 189 04 05	N. Boat-house	55 36 52 95 24 33	1936.9 1430.1	2118.1 1563.9	1.20 0.89
North Quarry	40 58 01.94	73 54 17.50	258 32 08 216 52 54	Hastings	337 23 58 9 04 16	2719.0 2405.7	2973.4 2630.8	1.69 1.50
Mechan	40 57 15.70	73 53 32.22	143 31 36 198 51 52	Baumer's Pier	78 32 54 36 53 31	1689.7 3339.9	1847.8 3707.1	1.05 2.10
South Quarry	40 57 56.04	73 54 19.06	318 37 45 253 01 59	North Quarry	323 31 05 18 52 09	1773.2 1861.4	1939.1 2035.5	1.10 1.16
Upper Closter	40 56 47.34	73 54 46.94	197 06 28 243 24 51	Baumer's Pier	138 38 16 73 02 47	1637.4 1774.3	1812.5 1940.3	1.03 1.10
Glenwood	40 56 50.28	73 53 42.85	157 20 21 197 37 38	South Quarry	17 06 46 63 25 41	2216.3 1954.1	2423.7 2137.0	1.38 1.21
Van Dusen's Observatory	41 02 38.12	73 51 14.35	35 16 11 51 17 18	Mechan	337 10 57 17 37 45	2196.9 822.0	2402.4 898.9	1.36 0.51
High Capola, S.	40 58 18.94	73 52 46.60	146 58 35 76 06 57	Duer	215 14 29 231 15 36	6318.4 4641.9	6909.6 5076.3	3.92 2.88
Lillienthal, flagstaff	40 57 23.10	73 53 07.64	121 19 02 64 37 00	Meadow Point	326 57 53 256 03 57	2768.9 2184.4	3027.9 2388.8	1.72 1.36
Upper Dobbs's Ferry, Methodist church.	41 00 53.74	73 52 04.69	97 21 24 51 52 33	North Quarry	301 18 15 244 35 55	1954.7 2570.8	2137.6 2811.4	1.22 1.60
				Upper Closter				
				Meadow Point	277 20 15 231 51 24	2466.1 3142.1	2696.9 3436.1	1.53 1.95
				Duer				
<i>Hudson River—Hudson to Troy.</i>								
Catskill	42 11 21.78	74 01 55.16						
Mount Merino	42 14 03.05	73 48 43.98	74 44 26	Catskill	254 35 54	18815.4	20575.9	11.60
Powell	42 23 18.65	73 51 31.23	347 23 26 32 55 47	Mount Merino	167 25 18 212 48 47	17564.4 26333.4	19207.9 28797.4	10.92 16.36
Merwin	42 21 21.68	73 41 03.42	104 09 49 37 58 47	Catskill	284 02 46 217 53 37	14808.6 17158.7	16194.3 18764.2	9.20 10.66
Yellow Pine	42 29 26.88	73 40 08.34	4 48 44 54 00 33	Powell	184 48 07 233 52 52	15022.5 19302.7	16428.1 21108.9	9.34 11.99
Stanton	42 27 00.48	73 52 06.45	254 32 11 304 31 23	Merwin	74 40 18 124 38 50	17012.9 18414.9	18604.8 20138.0	10.57 11.44
Traver	42 30 12.85	73 45 20.06	281 14 22 57 26 29	Yellow Pine	101 17 53 237 21 55	7256.9 11016.7	7935.9 12047.4	4.51 6.85
Blodgett	42 30 45.19	73 53 16.75	275 11 40 346 57 17	Stanton	95 17 02 166 58 05	10927.2 7116.1	11949.7 7782.0	6.79 4.42
Academy Hill	42 14 35.94	73 46 16.43	73 18 55 209 46 12	Traver				
				Stanton				
				Mount Merino	253 17 16 29 49 43	3531.8 14425.6	3862.3 15775.4	2.20 8.96
				Merwin				

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section II.—Hudson River—Hudson to Troy.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	Meters.	Yards.	Miles.
Hallenbeck, South.....	42 16 17.21	73 49 39.19	303 53 45 342 59 58	Academy Hill Mount Merino	123 56 01 163 00 35	5391.6 4328.4	6122.5 4733.4	3.48 2.69
Van Hoesen	42 18 18.79	73 53 34.54	319 48 55 304 22 05	Mount Merino Academy Hill	139 52 10 124 27 00	10293.0 12167.8	11288.9 13306.3	7.42 7.56
Hotchkiss	42 17 32.45	73 45 45.46	66 35 05 7 23 33	Hallenbeck, South..... Academy Hill	246 32 29 187 25 12	5836.2 5491.2	6382.3 6005.7	3.63 3.41
Tryon	42 18 42.03	73 47 28.77	347 40 46 312 12 35	Academy Hill Hotchkiss	167 41 34 132 13 46	7770.8 3194.8	8497.9 3493.7	4.83 1.98
Parade	42 15 50.71	73 47 31.23	308 50 43 120 44 35	Academy Hill Hallenbeck, South.....	128 51 33 300 43 09	2901.8 3411.4	2407.9 3730.6	1.37 2.12
Merino Point	42 14 49.48	73 48 33.68	150 58 22 230 02 42	Hallenbeck, South..... Parade	330 58 38 56 03 24	3093.4 1735.4	3385.0 1886.0	1.92 1.07
Wiswell	42 14 24.06	73 49 15.44	67 39 41 49 03 47	Goedes..... Rodger's Island, North.....	247 38 46 229 03 03	2017.8 2002.9	2206.6 2190.3	1.25 1.24
Nichols.....	42 15 26.72	73 48 47.24	344 51 34 358 20 59	Merino Point Mount Merino	164 51 43 178 20 52	1190.4 2582.5	1301.7 2824.1	0.74 1.60
Dober's Island.....	42 15 47.67	73 47 59.05	313 14 45 23 51 10	Academy Hill Merino Point	133 15 54 203 50 47	3239.6 1963.0	3531.8 2146.7	2.01 1.22
Railroad, 95.....	42 16 50.55	73 46 28.99	27 14 05 158 17 55	Parade	207 13 23	3117.3	3409.0	1.94
Grove Point.....	42 16 42.66	73 47 23.94	259 03 25 25 22 10	Tryon..... Railroad, 95	338 17 15 79 04 02	3761.9 1282.2	4048.3	2.30
Hallenbeck, North.....	42 18 36.55	73 49 25.31	329 44 30 266 22 15	Dober's Island..... Academy Hill	205 21 46 149 46 37	1877.7 8592.6	2053.4	0.80
Railroad, 94.....	42 15 29.49	73 47 24.15	52 14 21 125 02 30	Tryon..... Merino Point	86 23 34 233 13 34	2674.1 2015.8	2924.3	1.66
Athens Wharf.....	42 15 22.96	73 48 19.47	12 50 41 17 29 25	Dober's Island..... Mount Merino	305 02 07 102 50 24	976.7 2529.1	1068.1	0.61
Brandeau	42 14 48.27	73 49 54.03	12 50 41 243 42 50	Merino Point..... Mount Merino	197 29 16 131 00 11	1083.3 2127.1	1184.7	0.67
Porter	42 16 28.41	73 47 57.68	310 59 24 243 42 50	Athens Wharf..... Parade	63 43 54 163 49 31	2417.4 2174.9	2643.6	1.50
Athens, Dutch Reformed church ..	42 15 46.09	73 48 22.74	343 49 13 337 05 18	Railroad, 94..... Parade	157 05 41 123 33 33	1973.7 1416.6	2378.4	1.35
Athens, Episcopal church	42 15 52.00	73 48 08.28	290 52 06 318 40 04	Railroad, 94..... Parade	110 52 45 138 40 29	1437.0 1285.6	1571.4	0.89
Hudson, Episcopal church	42 14 58.22	73 47 02.96	304 28 34 302 48 12	Railroad, 94..... Academy Hill	124 29 04 129 48 43	1226.7 1269.1	1341.5	0.76
Hudson, Roman Catholic church ..	42 15 03.10	73 47 19.30	139 53 05 146 29 01	Dober's Island..... Hallenbeck, South.....	319 52 27 305 29 04	1994.6 3937.7	1387.9	0.79
Dubois.....	42 16 06.51	73 46 51.90	125 30 38 148 39 08	Hallenbeck, South..... Grove Point	305 29 04 326 38 46	4306.1	245.0	2.45
Quarry Point.....	42 17 33.18	73 47 07.66	201 07 36 326 02 01	Railroad, 95..... Railroad, 95	21 07 51 146 02 27	1456.6 1585.6	1798.7	0.91
Coventry.....	42 17 52.62	73 45 59.71	270 40 35 19 18 17	Hotchkiss..... Railroad, 95	90 41 30 199 17 57	1833.2 2020.1	2059.4	1.17
Coonly.....	42 17 25.90	73 47 15.08	41 48 00 315 55 44	Grove Point..... Railroad, 95.....	221 47 03 135 56 15	2894.9	3165.8	1.80
Adams.....	42 18 13.40	73 46 38.80	244 28 08 315 56 55	Coventry..... Hotchkiss	64 28 59 135 57 31	1913.0	1660.0	0.94
Budd's Hill.....	42 22 59.00	73 47 39.33	2092.0 305 36 03	Coventry..... Merwin	1203.9 108 22 37	1263.9	2092.0	1.19
Coxsackie Hill.....	42 20 55.33	73 47 28.30	288 18 10 96 32 44	Powell..... Merwin	276 30 08 34 45 40	5338.4 8845.2	10435.1	5.93
Stockport.....	42 18 41.24	73 46 03.55	367 30 08 264 41 21	Powell..... Merwin	308 29 07 34 45 40	7102.3	7766.9	4.42
Alvord.....	42 19 17.52	73 45 53.79	176 39 18 348 56 42	Coventry..... Hotchkiss	1502.6 168 56 54	1643.1	2364.8	0.94
Lamphear.....	42 18 58.54	73 46 48.56	240 00 51 63 16 45	Hotchkiss..... Merwin	2162.5 60 04 06	2364.8	8389.1	1.34
Reed.....	42 19 52.43	73 46 51.21	243 15 41 350 53 14	Tryon..... Adams	243 15 41 170 53 21	2434.8	2662.6	1.51
			297 21 51	Stockport.....	117 22 21	1410.4	1542.3	0.88
			357 54 24	Lamphear.....	153 34 54	1160.5	1269.0	0.72
					177 54 26	2452.4	2681.9	1.52
						1663.7	1819.3	1.04

REPORT OF THE SUPERINTENDENT OF
UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section II.—Hudson River—Hudson to Troy.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	<i>Metres.</i>	<i>Yards.</i>	<i>Miles.</i>
Reed, cupola	42 19 40.90	73 46 54.33	309 38 34 352 29 51	Railroad, 96	129 39 03	1271.9	1390.9	0.79
				Adams	172 30 01	2723.0	2977.8	1.69
Alger	42 19 44.96	73 45 44.56	132 27 10 98 34 31	Coxsackie Hill	312 26 00	3217.5	3518.6	2.00
				Reed	278 33 46	1543.5	1687.9	0.96
Railroad, 96	42 19 14.59	73 46 11.56	349 15 18 142 07 27	Hotchkiss	169 15 36	3207.1	3507.2	1.99
				Reed	322 07 00	1478.8	1617.2	0.92
Bronk	42 20 29.31	73 47 24.40	132 47 51 259 27 56	Powell	312 45 08	7693.3	8413.2	4.78
				Merwin	79 32 13	8867.4	9697.1	5.51
Stockport Hill	42 18 21.76	73 45 41.82	78 40 12 104 19 59	Adams	258 48 34	1330.5	1454.9	0.80
				Troy	284 18 47	2527.4	2763.9	1.57
Rider	42 21 51.82	73 46 34.62	111 34 25 35 11 03	Powell	291 31 05	7294.7	7977.2	4.53
				Coxsackie Hill	215 10 27	2132.3	2331.8	1.32
Warner	42 22 59.03	73 46 38.12	357 46 59 89 57 53	Rider	177 47 01	2074.9	2280.1	1.29
				Budd's Hill	269 57 12	1403.3	1531.3	0.87
Four-mile Point Light	42 18 10.96	73 46 41.92	233 13 35 311 05 53	Stockport	53 14 01	1007.1	1109.8	0.68
				Coventry	131 06 21	1222.9	1403.0	0.80
Eugenie	42 19 46.57	73 46 07.05	5 58 31 100 08 17	Railroad, 96	185 58 28	991.9	1084.7	0.62
				Reed	280 07 47	1027.2	1123.3	0.64
Fordham	42 20 38.38	73 46 34.07	338 51 47 179 41 34	Eugenie	158 52 05	1714.4	1874.8	1.07
				Rider	359 41 34	2266.1	2478.2	1.41
Practice	42 18 58.40	73 46 51.28	180 03 20 245 50 48	Reed	0 03 20	1665.9	1821.7	1.04
				Alvord	65 51 27	1442.6	1577.5	0.90
Worden	42 21 34.23	73 47 39.13	208 04 29 348 19 53	Warner	28 05 10	2965.1	3242.6	1.84
				Coxsackie Hill	168 20 00	1225.5	1340.2	0.76
Newton Hook	42 21 11.69	73 47 02.13	328 00 04 129 24 55	Fordham	148 00 23	1211.9	1325.3	0.75
				Worden	309 24 30	1095.5	1198.0	0.68
Canalboat	42 20 15.48	73 46 59.33	366 42 01 219 17 34	Eugenie	126 42 36	1492.6	1632.2	0.93
				Fordham	39 17 51	913.4	998.8	0.57
Baker's Pier	42 20 49.63	73 47 11.00	196 35 49 205 27 21	Newton Hook	16 35 55	710.2	776.6	0.44
				Rider	23 27 46	2091.8	2287.6	1.30
Upper Landing	42 21 53.04	73 47 33.33	345 21 45 356 18 01	Baker's Pier	165 22 00	2022.2	2211.4	1.26
				Coxsackie Hill	176 18 04	1784.2	1951.2	1.11
Hogpen	42 21 58.97	73 46 49.48	79 40 28 148 22 43	Upper Landing	259 39 59	1019.8	1115.2	0.63
				Budd's Hill	328 22 10	2175.0	2378.5	1.35
Budd	42 23 07.39	73 47 24.04	283 48 17 334 07 20	Warner	103 48 48	1081.8	1183.1	0.67
				Rider	154 07 53	2591.0	2833.4	1.61
Rocky Point	42 22 22.70	73 47 37.30	230 22 34 192 24 09	Warner	50 23 14	1757.5	1922.0	1.09
				Budd	12 24 18	1411.9	1544.0	0.88
Poplar Point	42 22 45.60	73 46 51.75	55 52 11 357 55 36	Rocky Point	235 51 40	1258.9	1376.7	0.78
				Hogpen	177 55 38	1439.6	1574.3	0.89
Slang Hook	42 20 29.33	73 49 08.71	40 31 18 69 45 55	Reed	220 30 49	1497.7	1637.8	0.93
				Canal Boat	249 45 21	1234.8	1350.3	0.77
Gillett	42 25 21.17	73 44 12.20	105 49 54 37 16 56	Stanton	285 44 34	11262.8	12316.6	7.00
				Warner	217 15 18	5510.5	6026.1	3.42
Middle Bronk	42 24 25.70	73 47 15.35	247 45 19 342 20 13	Gillett	67 47 23	4523.5	4946.7	2.81
				Warner	162 20 58	2906.2	3068.8	1.74
Bronk, North	42 25 39.56	73 47 04.58	6 10 01 353 02 08	Middle Bronk	186 09 54	2292.3	2506.8	1.42
				Warner	173 02 26	4989.7	5456.6	3.10
Bailey	42 23 47.78	73 46 29.19	46 49 58 137 56 23	Budd's Hill	226 49 11	2199.8	2405.6	1.37
				Middle Bronk	317 55 52	1575.6	1723.0	0.98
Coxsackie Light	42 22 44.59	73 47 23.36	325 35 00 212 25 43	Rider	145 34 33	1973.1	2157.7	1.23
				Bailey	32 26 20	2309.8	2525.9	1.43
Coxsackie, Episcopal church	42 21 09.15	73 47 53.67	331 24 50 233 56 49	Bronk	151 25 10	1399.9	1530.9	0.87
				Rider	53 57 42	2237.3	2446.7	1.39
Coxsackie, Roman Catholic church	42 20 56.00	73 47 26.06	214 20 56 228 31 10	Rider	34 21 31	2066.1	2281.3	1.29
				Newton Hook	48 31 26	730.6	799.0	0.45
Cove Point	42 24 05.26	73 47 18.13	2 44 47 295 43 23	Coxsackie Light	182 44 43	2491.7	2724.9	1.55
				Bailey	115 43 56	1242.4	1358.6	0.77
Old Steamboat Wharf	42 23 54.92	73 46 35.98	168 35 11 136 31 36	Bronk, North	348 32 52	3294.1	3602.3	2.05
				Middle Bronk	316 31 10	1308.4	1430.8	0.81
River Bluff	42 25 32.66	73 45 59.46	15 28 48 98 08 56	Old Steamboat Wharf	195 28 23	3129.2	3422.0	1.94
				Bronk, North	278 08 12	1503.6	1644.2	0.94

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section II.—Hudson River—Hudson to Troy.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- nuth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	Meters.	Yards.	Miles.
Covert	42 26 19.53	73 45 38.94	23 59 46 13 47 27	Budd's Hill..... Bailey	203 58 25 193 46 53	6771.7 4829.7	7495.4 5271.8	4.21 3.09
Railroad Bridge	42 24 43.82	73 46 13.38	145 46 13 18 54 28	Brook North..... Old Steamboat Wharf.....	325 45 38 198 54 43	2680.3 1594.8	2274.9 1744.0	1.29 0.99
Shufelt	42 28 29.03	73 40 17.08	80 29 50 58 12 10	Stanton	260 21 51 238 04 35	16433.6 18440.9	17971.2 19838.3	10.21 11.27
Nodine	42 27 29.99	73 47 20.98	208 46 52 82 04 49	Traver	28 48 13	5733.3	6269.8	3.56
Ten Eyek, 2.....	42 28 44.58	73 45 29.50	184 31 13 47 54 24	Stanton	262 01 36	6585.4	7201.6	4.09
Van Ness	42 27 36.12	73 44 52.31	83 42 53 242 11 20	Traver	4 31 19	2731.8	2987.4	1.70
Coeyman	42 28 09.88	78 47 21.35	359 36 24 216 07 12	Nodine	227 53 09	3432.1	3753.2	2.13
Lusher	42 31 24.29	73 46 15.54	318 28 47 6 23 23	Stanton	263 38 00	9979.4	10913.2	6.20
Eaton	42 25 06.80	73 45 46.06	153 51 31 119 23 34	Yellow Pine.....	62 14 32	7330.8	8016.8	4.56
Mull	42 30 01.56	73 46 48.40	9 02 38 260 11 57	Nodine	179 36 24	1239.6	1345.8	0.77
Hallenbeck	42 35 54.40	73 39 48.85	2 07 54 62 42 20	Traver	36 08 34	4697.5	5137.0	2.92
Thorp.....	42 33 18.44	73 43 46.31	325 07 51 79 05 19	Nodine	138 29 45	2943.8	3219.3	1.83
Ferris	42 40 34.95	73 44 53.58	321 14 35 32 16 22	Brook North.....	186 22 39	7253.8	7954.5	4.52
Ryesdorph	42 37 34.89	73 42 51.42	306 40 39 48 30 18	Nodine	333 50 27	4921.6	5382.2	3.06
Industrial School	42 39 03.04	73 46 16.64	304 10 05 301 50 11	Brook North.....	299 32 41	2600.0	2852.7	1.28
Bloomington.....	42 40 28.94	73 39 27.07	49 56 01 3 21 21	Nodine	189 02 16	4735.2	5178.3	2.94
Coast Survey Station	42 39 50.08	73 44 41.22	317 29 00 329 02 35	Traver	80 12 57	2046.4	2237.9	1.27
Roraback	42 29 31.29	73 44 41.60	180 01 33 209 26 25	Yellow Pine.....	182 07 41	1964.3	21383.7	7.44
Albany cathedral.....	42 38 49.54	73 45 16.13	76 17 54 188 58 05	Blodgett.....	242 33 14	20751.1	22692.6	12.89
Meridian.....	42 34 13.80	73 44 41.19	61 21 38 179 59 45	Yellow Pine.....	145 19 18	8705.6	9520.2	5.41
Troy University.....	42 43 44.43	73 40 40.90	344 25 41 44 32 50	Blodgett.....	245 58 54	13848.4	15144.2	8.60
Van Aernam	42 42 13.45	73 44 08.54	279 15 32 296 41 30	Hallenbeck	141 18 01	11095.8	12133.9	6.89
Lansing	42 44 11.12	73 42 39.17	287 00 12 327 27 25	Blodgett.....	212 10 41	21509.6	23522.2	13.36
Lansingburgh Spire.....	42 46 27.38	73 40 14.63	6 46 36 38 01 40	Hallenbeck	126 42 43	5188.7	5674.2	3.22
Sherman	42 26 26.45	73 46 57.40	298 03 56 164 38 13	Blodgett.....	228 23 15	19056.5	20889.6	11.84
Reed	42 27 10.92	73 45 47.04	49 32 13 105 20 54	Hallenbeck	124 14 28	10683.3	11682.9	6.64
Ten Eyek, 1.....	42 28 48.10	73 45 33.63	5 50 04 45 30 32	Ryesdorph	121 52 36	5504.1	6019.1	3.42
Stuyvesant Light.....	42 24 40.03	73 46 23.15	198 12 52 69 40 23	Ryesdorph	220 53 43	7106.3	7771.3	4.42
Railroad	42 26 11.90	73 46 01.45	109 21 13 357 52 06	Hallenbeck	183 21 06	8455.2	9279.2	5.27
Wood Wharf	42 25 29.82	73 46 46.89	340 33 00 297 03 21	Hallenbeck	137 32 18	9861.3	10784.0	6.13
Sutherland	42 24 46.93	73 47 00.57	193 17 52 283 58 58	Ryesdorph	149 03 49	4893.6	5318.6	3.02
				Coast Survey Station.....	0 01 33	19991.7	21878.1	11.86
				Hallenbeck	29 29 43	13576.2	14846.5	8.44
				Blodgett	216 12 29	18531.3	20265.2	11.51
				Ferris	8 58 20	3292.5	3600.5	2.05
				Blodgett	241 15 49	13408.3	14662.9	8.33
				Coast Survey Station.....	359 59 45	10575.6	11346.4	6.45
				Bloomington	164 26 31	6361.7	6847.6	3.89
				Ferris	224 29 59	8200.5	8967.8	5.10
				Troy University	59 17 53	5495.3	6009.5	3.41
				Bloomington	116 44 41	7172.4	7843.5	4.46
				Troy University	107 01 32	2813.4	3076.6	1.75
				Bloomington	147 29 35	8130.5	8891.2	5.05
				Troy University	186 46 18	5062.8	5536.6	3.15
				Lansing	218 09 02	5336.3	5835.6	3.32
				Gillett	118 05 47	4279.2	4679.6	2.66
				Nodine	344 37 57	2033.1	2223.3	1.25
				Sherman	229 31 26	2113.7	2311.4	1.31
				Nodine	285 19 51	2225.5	2433.7	1.38
				Reed	185 49 55	3014.0	3296.0	1.87
				Nodine	225 29 20	3497.2	3759.5	2.14
				Covert	18 13 22	3231.0	3533.3	2.01
				Middle Brook.....	1272.5	1391.5	1391.5	0.79
				Sherman	289 29 35	1355.2	1482.0	0.84
				River Bluff.....	177 52 07	1211.3	1324.6	0.75
				Stuyvesant Light.....	160 33 16	1629.4	1781.9	1.01
				Eaton	117 04 02	1561.2	1707.3	0.97
				Wood Wharf.....	13 18 01	1359.8	1487.0	0.84
				Stuyvesant Light.....	103 39 23	881.6	964.1	0.55

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section II.—Hudson River—Hudson to Troy.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	Meters.	Yards.	Miles.
Muitze's Kill Church	42 28 33.74	73 43 32.53	76 16 41 106 58 00	Stanton	256 10 54	13067.5	13218.5	7.51
				Blodgett	286 51 25	13941.8	15246.4	8.66
Barren Island, north	42 28 03.76	73 46 52.40	32 04 47 317 30 40	Nodine	212 04 28	1220.4	1344.5	0.76
				Reed	137 31 24	2210.8	2417.7	1.37
Burns' Wharf	42 27 11.93	73 46 03.14	107 24 32 144 52 16	Nodine	287 23 40	1863.5	2037.8	1.16
				Barren Island, north	324 51 43	1955.3	2138.3	1.22
Railroad, 29	42 27 26.92	73 46 02.97	135 11 44 0 28 24	Barren Island, north	315 11 11	1602.1	1752.0	1.00
				Burns' Wharf	180 28 24	462.4	505.6	0.29
Barren Island, south	42 28 20.03	73 47 13.51	329 50 13 354 00 22	Covert	149 51 17	4300.3	4702.6	2.68
				Sherman	174 00 33	3523.4	3853.1	2.19
Bethlehem	42 33 41.46	73 48 00.11	276 57 43 53 01 55	Thorp	97 00 35	5839.0	6385.3	3.63
				Blodgett	232 58 21	9037.2	9883.1	5.62
Houterbarraek	42 35 47.23	73 40 02.63	48 01 58 130 49 32	Thorp	227 59 27	6802.2	7504.2	4.26
				Ryesdorph	310 47 38	5082.2	5537.7	3.16
Burrill	42 39 28.40	73 43 36.02	62 16 06 139 18 30	Cathedral	242 14 52	2776.0	2917.1	1.60
				Ferris	319 17 37	2708.3	2961.7	1.68
Fish-house Branch	42 41 13.43	73 42 17.40	28 53 24 71 32 46	Burrill	208 54 30	3702.3	4048.7	2.30
				Ferris	251 31 00	3748.5	4099.2	2.33
Forbes	42 40 20.71	73 42 51.43	49 31 33 98 59 03	Cathedral	229 29 55	4332.7	4738.2	2.69
				Ferris	278 57 40	2815.6	3079.0	1.73
Van Rensselaer	42 39 00.33	73 43 18.65	143 29 20 82 54 55	Ferris	323 28 16	3632.5	3972.4	2.26
				Cathedral	262 53 35	2606.3	2848.6	1.67
East	42 37 52.74	73 44 01.05	127 19 40 166 33 32	Industrial School	307 18 08	3883.4	4246.8	2.41
				Ferris	346 32 56	5145.8	5627.2	3.20
Albany, Presbyterian church	42 39 02.68	73 44 52.82	245 35 16 314 23 37	Burrill	65 36 08	1920.6	2100.4	1.19
				Ryesdorph	134 24 59	3871.0	4233.2	2.41
Bloomingsdale, 2	42 41 09.61	73 42 13.60	73 42 23 126 50 53	Ferris	253 40 34	3808.8	4165.2	2.37
				Van Aernam	306 49 35	3285.5	3592.9	2.04
De Freestville Spire	42 39 08.67	73 41 29.57	32 48 05 119 49 56	Ryesdorph	212 47 10	3442.3	3764.4	2.14
				Ferris	299 47 38	3364.1	3685.1	2.33
One Mile	42 40 28.33	73 43 52.19	279 37 45 348 44 11	Forbes	99 38 26	1403.2	1534.5	0.87
				Burrill	168 44 22	1885.3	2061.7	1.17
Toll Gate	42 41 01.84	73 43 31.13	324 31 49 2 12 56	Forbes	144 32 16	1557.7	1703.4	0.97
				Burrill	182 12 53	2885.0	3155.0	1.79
Borden's Observatory	42 42 07.53	73 41 22.12	155 19 00 319 15 57	Lausling	335 18 08	4196.9	4589.6	2.61
				Bloomingsdale	139 17 15	4014.2	4389.8	2.49
Centre	42 44 02.27	73 41 17.76	98 23 28 303 16 56	Lausling	278 22 33	1871.8	2047.0	1.16
				Troy University	123 17 21	1902.8	2096.7	0.63
St. Peter	42 44 15.14	73 40 48.32	87 11 31 50 31 15	Lausling	267 10 16	2524.3	2760.5	1.57
				Van Aernam	230 28 59	5002.9	5455.3	3.67
Arsenal	42 43 15.19	73 41 55.04	241 50 44 57 54 54	Troy University	61 51 34	1912.8	2091.8	1.19
				Van Aernam	227 53 24	3585.4	3920.9	2.23
Dutch Reformed Church Spire	42 42 59.87	73 41 54.97	230 46 51 64 46 44	Troy University	50 47 41	2175.0	2378.5	1.35
				Van Aernam	244 45 13	3359.6	3674.0	2.09
St. John	42 43 30.50	73 41 20.20	244 19 06 58 11 06	Troy University	64 19 33	992.0	1084.8	0.62
				Van Aernam	238 09 12	4507.9	4929.7	2.80
Rand	42 42 21.57	73 41 27.57	86 06 11 154 16 27	Van Aernam	266 04 22	3671.5	4015.0	2.28
				Lausling	334 15 38	3752.6	4103.7	2.33
Green	42 41 26.98	73 41 59.70	116 04 10 169 56 51	Van Aernam	296 02 43	3263.8	3569.2	2.03
				Lausling	349 56 24	5143.2	5624.4	3.20
Logan's Bar	42 41 23.58	73 42 09.91	119 41 25 208 18 21	Van Aernam	299 40 05	3107.4	3398.2	1.93
				Rand	28 18 50	2032.1	2222.2	1.26
Greenbush, Roman Catholic church	42 38 24.36	73 44 01.45	163 35 16 221 17 13	Ferris	343 34 41	4200.5	4593.5	2.61
				Van Rensselaer	41 17 42	1477.3	1615.6	0.92
Greenbush Church	42 38 08.93	73 44 37.34	175 18 17 293 30 46	Ferris	355 18 06	4520.3	4943.2	2.81
				Ryesdorph	113 31 58	2632.0	2878.3	1.64
Tower	42 36 04.56	73 47 39.63	271 37 47 37 39 57	Hallenbeck	91 43 06	10735.3	11739.8	6.67
				Blodgett	217 56 09	12498.8	13668.3	7.76
Schuyler's Bridge	42 42 24.94	73 42 24.10	274 37 29 342 45 09	Rand	94 38 07	1290.6	1411.4	0.80
				Green	162 45 26	1872.4	2047.6	1.16
Hillhouse Bridge	42 41 51.68	73 42 49.86	243 46 44 303 43 20	Rand	63 47 40	2087.4	2282.7	1.30
				Green	123 43 54	1372.5	1500.9	0.85

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section II.—Hudson River—Hudson to Troy.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	Metres.	Faths.	Miles.
Wright's Bridge	42 41 36.82	73 43 06.63	201 27 24 269 48 37	Hill-house Bridge	26 27 36 89 49 22	856.7 1523.2	936.8 1655.7	0.53 0.95
Empire, Roman Catholic church....	42 41 29.50	73 42 33.92	223 13 27 275 41 19	Rand	43 14 12	2294.8	2411.1	1.37
Shawl Factory	42 42 35.13	73 42 03.59	221 20 09 76 46 01	Green	95 41 42	782.7	856.0	0.49
West Troy, Dutch Reformed church.	42 43 32.16	73 41 46.36	135 01 08 255 43 39	Troy University	41 21 05	2847.9	3114.3	1.77
Winslow	42 42 12.51	73 41 45.80	19 58 38 90 31 27	Van Aersman	256 44 36	2920.9	3194.2	1.82
Mann	42 42 47.29	73 41 38.28	9 03 16 15 34 27	Lansing	315 00 32	1699.3	1858.3	1.05
				Troy University	75 44 24	1536.5	1689.3	0.96
				Logan's Bar	109 58 22	1606.3	1756.6	1.09
				Van Aersman	270 29 50	3248.2	3552.2	2.02
				Winslow	189 03 11	1086.6	1188.3	0.68
				Logan's Bar	195 34 06	2621.1	2832.0	1.67

Section III.—Upper Patuxent River, Maryland.

Gilliam	38 21 20.92	76 29 56.92						
Hungerford	38 21 09.02	76 28 21.72	99 01 44	Gilliam	279 00 45	2340.0	2558.9	1.45
Peterson, 2	38 23 28.65	76 30 05.65	356 55 03 329 37 19	Gilliam	176 55 08	3943.7	4312.7	2.45
Settlerly Point, 2	38 22 55.65	76 31 50.36	248 10 20 302 58 21	Hungerford	149 38 24	4989.5	5456.4	3.10
Broom's Island, 2	38 24 09.08	76 32 57.21	324 22 15 286 39 15	Peterson, 2	68 11 25	2737.0	2993.0	1.70
High Bank, 2	38 23 16.27	76 33 00.84	183 05 51 264 51 18	Hungerford	123 00 30	6037.9	6602.8	3.75
Bond	38 25 37.84	76 34 31.33	333 17 33 320 09 21	Settlerly Point, 2	144 22 56	2784.8	3045.3	1.73
Maud's Hill	38 24 38.92	76 36 03.71	299 51 18 230 37 49	Peterson, 2	106 41 01	4345.1	4751.7	2.70
Parker	38 25 20.84	75 34 01.84	338 55 21 66 23 34	Broom's Island, 2	3 05 53	1630.4	1782.9	1.01
Ayers, 2	38 26 03.92	76 35 13.87	24 46 04 307 14 23	Peterson, 2	84 53 07	4268.1	4667.5	2.65
Reeder, 2	38 25 53.79	76 37 46.66	312 44 12 265 10 06	High Bank, 2	153 18 29	4885.5	5342.6	3.04
Duke, 2	38 28 16.40	76 37 47.00	317 43 07 359 53 39	Broom's Island, 2	140 10 19	3563.9	3897.4	2.21
McDaniel, 2	38 28 07.45	76 39 28.18	329 08 37 263 34 32	High Bank, 2	119 53 12	5116.4	5595.1	3.18
Holland's Point, 2	38 30 09.83	76 39 29.87	324 30 31 359 22 36	Bond	50 58 46	2884.6	3154.5	1.79
Sheridan's Point	38 28 00.75	76 38 26.01	242 58 03 158 45 24	High Bank, 2	158 55 59	4115.9	4501.0	2.56
Washington, 2	38 30 46.42	76 41 15.36	332 04 21 293 48 42	Maud's Hill	246 22 18	3226.2	3528.1	2.00
Godg's Graces Point	38 32 24.41	76 39 44.21	355 12 51 36 09 39	Maud's Hill	204 45 33	2885.9	3155.9	1.79
Estep	38 31 09.29	76 41 15.51	305 36 34 223 39 43	Parker	127 15 08	2194.2	2389.5	1.36
Barker	38 33 26.98	76 40 48.40	321 08 19 8 47 39	Maud's Hill	132 45 16	3400.6	3718.8	2.11
Town Point	38 30 49.29	76 40 04.72	87 03 08 189 36 32	Ayres, 2	85 11 41	3718.4	4066.3	2.31
Stanforth	38 33 45.83	76 39 52.48	355 26 17 66 45 27	Ayres, 2	137 44 42	5519.5	6006.0	3.43
Teneman's Point	38 34 13.89	76 40 50.31	358 10 08 301 42 49	Reeder, 2	179 53 39	4396.8	4808.2	2.73
Blake	38 34 53.99	76 40 03.93	352 29 13 42 14 10	Reeder, 2	149 09 40	4860.1	5249.2	2.98
Somerville, 2	38 35 40.89	76 40 41.35	4 37 10 327 56 31	Duke, 2	83 35 35	2408.0	2608.9	1.53
				Duke, 2	144 31 35	4211.8	4606.6	2.67
				McDaniel, 2	179 22 37	3773.3	4126.4	2.34
				Duke, 2	62 58 27	1061.7	1161.1	0.66
				Holland's Point, 2	338 44 44	4270.0	4669.5	2.65
				McDaniel, 2	152 05 28	5546.8	6065.8	3.45
				Holland's Point, 2	113 49 48	2793.4	3054.8	1.74
				Holland's Point, 2	175 13 00	4164.0	4553.6	2.59
				Washington, 2	216 08 42	3741.8	4091.9	2.32
				God's Graces Point	125 37 40	3147.9	3442.4	1.96
				God's Graces Point	43 40 40	3202.1	3501.7	1.99
				God's Graces Point	141 08 59	2477.0	2708.7	1.54
				Estep	188 47 22	4295.6	4697.5	2.67
				Washington, 2	267 02 24	1713.4	1873.7	1.06
				God's Graces Point	9 36 45	2974.5	3252.8	1.85
				God's Graces Point	175 26 22	2518.4	2754.1	1.56
				Barker	246 44 52	1473.1	1611.0	0.92
				Barker	178 10 09	1447.2	1582.6	0.90
				Stanforth	121 43 25	1799.4	1939.4	1.02
				Stanforth	172 29 20	2119.6	2317.9	1.32
				Teneman's Point	222 13 41	1669.8	1826.0	1.04
				Teneman's Point	184 37 04	2691.1	2942.9	1.67
				Blake	147 56 54	1706.1	1865.8	1.06

Section III.—Upper Patuxent River, Maryland.—Continued.

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	<i>Metres.</i>	<i>Yards.</i>	<i>Miles.</i>
Holland's Cliffs	38 36 31.28	76 39 54.46	4 22 14 36 08 30	Blake	184 22 08	3008.4	3229.9	1.87
				Somerville, 2	216 08 01	1923.8	2103.9	1.20
Covington	38 37 03.96	76 41 30.79	332 19 09 203 22 29	Blake	152 20 03	4534.8	4948.1	2.81
				Holland's Cliffs	113 23 29	2536.7	2776.2	1.58
Sollin	38 37 51.28	76 40 25.19	343 13 38 47 24 33	Holland's Cliffs	163 13 57	2576.0	2817.1	1.60
				Covington	227 23 52	2155.4	2357.1	1.34
Bowling's Marsh	38 37 09.66	76 40 10.51	92 00 32 167 10 59	Covington	272 59 42	1944.5	2126.4	1.21
				Sallin	347 10 50	1601.0	1750.8	1.00
High Hill	38 37 51.80	76 41 23.79	357 10 50 270 32 52	Covington	177 10 52	1476.7	1614.9	0.92
				Sallin	90 33 35	1659.2	1814.5	1.03
Lower Marlborough	38 38 49.64	76 40 42.70	346 41 26 34 40 05	Sallin	166 41 37	1849.3	2022.4	1.15
				High Hill	214 39 33	2108.4	2371.3	1.35
Magruder's Ferry	38 38 39.14	76 41 38.58	309 44 05 256 29 31	Sallin	129 44 51	2308.2	2524.2	1.43
				Lower Marlborough	76 30 06	1327.4	1517.2	0.86
Fowler	38 39 57.86	76 40 50.56	354 53 49 25 34 08	Lower Marlborough	174 53 54	2111.5	2309.0	1.31
				Magruder's Ferry	205 33 38	2080.5	2242.2	1.07
Perry	38 39 55.63	76 41 58.09	318 56 17 267 31 08	Lower Marlborough	128 57 03	2608.2	2850.7	1.68
				Fowler	87 31 49	1585.7	1734.0	0.99
Jones, 1	38 41 23.37	76 41 18.04	345 51 24 18 46 47	Fowler	165 51 41	2719.0	2973.4	1.69
				Perry	198 46 23	2857.1	3124.5	1.78
Bald Eagle	38 40 53.99	76 42 08.64	233 28 02 312 30 59	Jones, 1	53 28 34	1521.7	1664.1	0.95
				Fowler	132 31 48	2560.8	2800.4	1.59
Turton	38 42 19.31	76 41 52.75	334 04 08 8 18 22	Jones, 1	154 04 30	1918.0	2097.4	1.19
				Bald Eagle	188 18 12	2058.6	2207.4	1.25
Ravine	38 41 55.12	76 41 18.50	32 41 31 132 02 07	Bald Eagle	212 44 00	2240.6	2450.3	1.39
				Turton	312 01 46	1114.2	1218.5	0.69
Wharf Marsh	38 42 25.93	76 41 27.47	347 08 55 71 31 18	Ravine	167 09 02	974.5	1065.7	0.61
				Turton	251 31 02	643.9	704.2	0.40
Reed	38 42 52.47	76 41 45.95	331 22 42 9 07 36	Wharf Marsh	151 24 00	932.2	1019.4	0.58
				Turton	189 07 32	1035.6	1132.5	0.64
Griffith	38 43 39.64	76 41 11.67	9 32 07 29 39 42	Wharf Marsh	189 31 57	2204.4	2520.0	1.43
				Reed	209 39 21	1673.5	1830.1	1.04
Bis Jones	38 41 32.25	76 41 16.05	47 08 31 148 34 26	Bald Eagle	227 07 58	1734.0	1896.3	1.08
				Turton	328 34 03	1700.7	1859.9	1.06
Number 2	38 41 44.25	76 41 45.70	171 03 10 297 18 01	Turton	351 03 06	1094.6	1197.0	0.68
				Bis Jones	117 18 20	806.5	882.0	0.50

Section X.—Primary Points, San Francisco Bay to Tomales Bay, Drake's Bay, Tomales Bay to Slavianska River, and Monterey Harbor.

<i>Primary Points.</i>								
Pulgas Base, west end	37 28 39.30	122 14 17.03						
Pulgas Base, east end	37 28 26.79	122 07 09.48	92 08 22	West Base	272 04 02	10512.1	11495.7	6.53
Guano Island	37 34 14.21	122 14 44.84	356 12 51 313 43 40	West Base	176 13 06	10316.5	11314.6	6.43
				East Base	133 48 17	15482.8	16931.6	9.92
Pise Hill	37 27 34.58	122 19 37.31	264 55 53 210 12 57	East Base	85 03 29	18446.0	20172.0	11.46
				Guano Island	30 15 55	14259.4	15593.7	8.86
Red Hill	37 32 55.29	122 04 42.27	23 36 01 99 23 38	East Base	203 34 31	9031.4	9876.4	5.61
				Guano Island	279 17 31	14966.0	16388.3	9.31
Ridge	37 30 36.57	122 21 32.02	236 05 37 333 19 18	Guano Island	56 09 45	12037.8	13164.1	7.48
				Pise Hill	153 20 28	6278.0	6865.4	3.90
Rocky Mound	37 52 47.92	122 13 31.90	340 31 24 16 01 50	Red Hill	160 36 48	38987.0	42635.1	24.22
				Ridge	195 56 56	42694.1	46689.0	26.53
Table Mountain	37 55 18.12	122 34 46.79	336 51 06 278 20 54	Ridge	156 59 12	49646.9	54292.3	30.85
				Rocky Mound	98 33 57	31485.0	34431.1	19.56
Sonoma Mountain	38 19 15.36	122 33 29.51	2 26 20 322 05 45	Table Mountain	182 25 32	44349.5	48499.3	27.56
				Rocky Mound	149 18 04	56976.7	62398.0	35.40
Tomales Bay	38 10 46.18	122 55 48.50	312 49 16 244 08 26	Table Mountain	133 02 14	42008.2	45938.9	26.10
				Sonoma Mountain	64 22 15	36140.5	39522.1	22.46

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section X.—Primary Points, Drake's Bay, Tomales Bay to Slaviaska River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	D. I. "	O. I. "	D. I. "		D. I. "	Meters.	Yards.	Miles.
Ross Mountain.....	38 30 11.37	123 06 11.12	292 51 30 337 07 23	Sonoma Mountain	113 11 49	51701.3	55542.3	32.13
				Tomales Bay.....	157 13 49	38975.2	42632.1	24.22
Sulphur Peak.....	38 45 45.22	122 49 42.06	334 15 18 39 48 13	Sonoma Mountain	154 25 24	54321.9	59170.4	33.79
				Ross Mountain.....	219 37 56	37431.9	40631.4	23.26
Walalla Mount.....	38 51 15.61	123 28 52.47	319 42 53 279 58 48	Ross Mountain.....	139 57 04	51009.4	55782.4	31.69
				Sulphur Peak.....	100 23 21	57611.0	62001.7	35.80
Sanel Mount.....	38 56 46.77	123 12 02.34	350 11 06 352 08 44	Ross Mountain.....	170 14 46	48916.7	54587.4	31.02
				Sulphur Peak.....	122 22 45	38212.7	41788.3	23.74
Mount Diablo.....	37 52 46.19	121 53 49.61	130 34 07 94 40 18	Sonoma Mountain	309 59 39	75065.4	82009.0	47.16
				Table Mountain.....	274 15 09	60205.9	65839.3	37.41
<i>Drake's Bay.</i>								
Punta Reyes Hill.....	38 04 20.01	122 51 02.51	223 23 12 148 25 20	Sonoma Mountain	43 34 03	37232.4	40716.2	23.13
				Tomales Bay.....	328 22 24	13290.7	14531.3	8.26
Bodega Head.....	38 18 20.03	123 02 47.25	167 18 36	Ross Mountain.....	347 16 32	22482.2	24585.9	13.97
Richards.....	38 03 53.74	122 57 00.63	187 51 43	Tomales Bay.....	7 52 27	12835.6	14036.6	7.98
Punta Reyes Head.....	37 59 38.90	122 58 52.50	282 12 46 208 03 52	Table Mountain.....	102 28 12	37621.7	41142.0	23.38
				Richards.....	28 05 38	8901.0	9737.2	5.53
Steele.....	38 02 02.14	122 53 00.78	210 46 25 66 18 40	Punta Reyes Hill.....	30 47 38	5631.9	6158.9	3.50
				Punta Reyes Head.....	246 14 27	10969.0	11965.3	6.82
Estero.....	38 02 02.54	122 55 38.87	234 21 23 54 26 36	Punta Reyes Hill.....	54 24 13	8286.7	9032.1	5.15
				Punta Reyes Head.....	234 24 00	7606.0	8317.7	4.73
Number 1.....	38 01 32.05	122 51 31.51	186 59 01 74 07 28	Punta Reyes Hill.....	6 59 19	5809.3	6352.9	3.61
				Punta Reyes Head.....	254 02 20	12707.4	13896.4	7.90
Number 2.....	38 00 50.08	122 49 50.20	80 30 43 165 26 01	Punta Reyes Head.....	260 24 32	14898.5	16292.6	9.26
				Punta Reyes Hill.....	345 25 16	7007.9	7633.0	4.35
Number 3.....	38 00 00.17	122 48 31.42	87 48 31 129 09 47	Punta Reyes Head.....	267 41 32	16628.6	18181.5	10.33
				Richards.....	300 04 33	14353.1	15698.3	8.92
Punta Reyes, east.....	37 59 17.49	122 56 55.86	98 45 43 253 10 40	Punta Reyes Head.....	278 43 54	4360.6	4768.7	2.71
				Number 2.....	73 15 02	10845.8	11896.6	6.74
Astronomical Station, Punta Reyes	37 59 35.04	122 57 36.06	225 58 13 257 00 57	Punta Reyes Hill.....	45 42 15	13414.0	14669.2	8.33
				Number 2.....	77 11 44	11655.4	12746.0	7.24
Punta Reyes, light-house site.....	37 59 39.36	123 00 13.32	210 54 08 235 25 25	Richards.....	30 56 07	9144.6	10000.2	5.68
				Punta Reyes Hill.....	55 31 04	16301.8	17827.2	10.13
Wild Cat.....	37 58 51.25	122 46 44.72	94 26 49 121 53 39	Punta Reyes Head.....	274 18 44	19277.5	21081.3	11.98
				Richards.....	301 47 20	17681.4	19335.6	10.99
Joyce.....	37 56 29.02	122 44 07.14	104 19 36 125 04 27	Punta Reyes Head.....	284 09 45	23804.0	26031.4	14.79
				Richards.....	305 56 31	23325.3	25307.8	14.49
Perrot.....	37 56 51.24	122 45 44.45	104 06 10 128 21 41	Punta Reyes Head.....	280 57 28	21333.0	23329.1	13.26
				Richards.....	308 14 45	21018.7	22985.4	13.06
Rock.....	37 45 44.76	123 04 41.14	209 41 17 247 54 02	Punta Reyes Hill.....	29 49 40	40279.2	44048.2	25.03
				Table Mountain.....	68 12 23	47294.0	51719.3	29.39
Middle Farallone.....	37 43 31.62	123 00 54.86	200 16 16 240 16 09	Punta Reyes Hill.....	26 22 20	41665.1	45563.7	25.89
				Table Mountain.....	60 32 11	44098.4	48224.7	27.40
North Farallone, south islet.....	37 45 42.92	123 04 53.55	210 01 12 247 58 23	Punta Reyes Hill.....	30 09 43	40479.5	44267.2	25.15
				Table Mountain.....	68 16 52	47596.8	52050.4	29.57
North Farallone, middle islet.....	37 45 52.94	123 04 59.84	210 25 41 248 23 10	Punta Reyes Hill.....	30 34 16	40290.0	44059.9	25.03
				Table Mountain.....	68 41 42	47624.8	52081.0	29.59
North Farallone, north islet.....	37 46 10.91	123 05 25.11	211 35 09 249 16 06	Punta Reyes Hill.....	31 43 59	40133.8	43889.2	24.94
				Table Mountain.....	69 34 34	48062.4	52494.0	29.83
<i>Tomales Bay to Slaviaska River.</i>								
Mount Helena.....	38 40 02.05	122 36 59.61	66 54 01 119 56 36	Ross Mountain.....	246 35 48	46132.9	50449.6	28.66
				Sulphur Peak.....	299 48 39	21240.6	23228.1	13.20
Bodega.....	38 18 14.46	122 59 05.53	266 59 11 340 51 51	Sonoma Mountain	87 15 04	37358.9	40854.5	23.21
				Tomales Bay.....	160 53 53	14627.4	15996.1	9.09
Bodega Hill.....	38 22 04.13	123 02 23.49	4 46 33 325 42 46	Bodega Head.....	184 46 18	6933.5	7582.2	4.31
				Bodega.....	145 50 49	8539.0	9359.8	5.32
Ocean Beach.....	38 19 47.99	123 02 56.06	355 29 25 297 13 43	Bodega Head.....	175 29 30	2720.5	2975.0	1.69
				Bodega.....	117 16 06	6298.3	6887.6	3.91
Bay Beach.....	38 18 40.31	123 01 44.33	67 45 05 140 09 00	Bodega Head.....	247 44 26	1651.5	1806.0	1.03
				Ocean Beach.....	320 08 16	2718.2	2972.6	1.69

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section X.—Tomales Bay to Slarianska River, Monterey Harbor.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azi- muth.	Distance.	Distance.	Dis- tance.
	° ' "	° ' "	° ' "		° ' "	Metres.	Yards.	Miles.
Astronomical Station, Bodega	38 18 20.59	123 02 17.45	272 18 23 178 46 53	Bodega	92 20 27	4666.3	5102.9	2.90
Redwood	38 24 02.84	123 00 18.13	18 55 19 350 40 24	Bodega Hill	358 46 49	6893.7	7538.7	4.28
Chaparral	38 29 24.76	123 09 58.12	305 09 57 332 56 12	Bodega Head	198 53 46	11171.8	12217.2	6.94
Benitz	38 29 51.19	123 09 53.33	307 33 13 322 48 46	Bodega Head	170 41 09	10883.9	11902.3	6.76
Bodega Reek	38 17 37.87	123 01 53.75	254 33 32 174 58 34	Redwood	125 15 58	17212.1	18822.6	10.69
Lagoon	38 18 32.86	123 00 27.79	83 20 50 156 40 45	Bodega Hill	133 00 39	23006.4	25159.1	14.30
Estero	38 17 06.92	122 58 36.83	110 20 54 161 29 10	Bodega Head	127 39 11	17662.3	19249.3	10.94
Inlet	38 16 19.95	122 58 03.76	118 26 51 157 38 36	Bodega Hill	142 53 26	18065.4	19755.8	11.23
Tomales Bluff	38 14 15.36	122 58 40.17	141 29 49 175 13 18	Bodega	74 35 16	4239.7	4636.4	2.63
Sand Hill	38 20 01.55	123 02 38.40	302 32 34 19 42 08	Bodega Hill	354 58 16	8241.0	9012.1	5.12
Dougherty's House, southwest gable	38 19 55.62	123 02 03.81	305 44 51 54 09 11	Bodega Head	261 19 24	3410.9	3730.1	2.12
Dr. Pigot's House, southwest gable	38 19 14.30	123 01 11.94	112 20 37 356 42 34	Bodega Head	336 39 33	7093.9	7757.7	4.41
Salmon Creek	38 21 13.70	123 02 59.92	314 07 53 170 09 57	Ocean Beach	290 18 19	6488.5	7095.6	4.03
Rocky Point	38 23 30.35	123 04 42.64	321 28 15 308 11 34	Bodega	341 28 52	2196.1	2401.6	1.36
Peaked Hill	38 25 44.49	123 06 06.31	323 23 02 179 11 25	Bodega Head	298 23 57	7777.4	8505.1	4.83
Russian River	38 27 42.82	123 07 43.06	325 23 02 321 28 15	Bodega	337 37 59	5817.4	6317.6	3.37
Dry Creek	38 28 22.68	123 08 41.10	327 18 55 321 50 39	Bodega Head	321 27 16	9641.7	10543.9	5.99
Monterey Harbor.				Bodega	355 13 02	7397.3	8029.5	4.60
Azimuth Point	36 35 30.91	121 51 52.54		Bodega Head	183 55 51	3137.3	3430.9	1.95
Rocky Point	36 36 49.14	121 52 44.34		Bodega	122 34 46	6134.4	6708.4	3.81
Sand Hill	36 36 07.76	121 51 15.94		Bodega Head	199 41 41	3130.4	3423.3	1.95
Monterey Bay	36 37 35.93	121 49 30.67		Bodega	125 46 41	5336.4	5835.7	3.32
Astronomical Station	36 37 59.29	121 54 25.00		Bodega Head	234 08 12	2856.6	3123.9	1.77
West Base	36 36 03.48	121 52 10.20		Ocean Beach	292 19 32	2731.8	2989.6	1.70
Round Hill	36 33 49.89	121 51 27.97		Bodega Head	176 42 42	5363.5	5865.3	3.33
				Bodega	134 10 19	7933.6	8673.9	4.93
				Ross Mountain	350 09 02	12548.6	13722.8	7.80
				Bodega Hill	128 13 00	4297.5	4699.6	2.67
				Ross Mountain	359 11 22	8928.8	8998.7	5.11
				Bodega Hill	141 30 33	8682.1	9494.5	5.39
				Ross Mountain	25 57 16	5093.2	5569.8	3.16
				Bodega Hill	143 26 21	13004.9	14221.8	8.08
				Ross Mountain	47 20 28	4943.6	5406.1	3.07
				Bodega Hill	141 54 34	14835.9	16224.1	9.22
Azimuth Point	36 35 30.91	121 51 52.54						
Rocky Point	36 36 49.14	121 52 44.34	331 53 59	Azimuth Point	151 54 30	2733.4	2989.1	1.70
Sand Hill	36 36 07.76	121 51 15.94	38 41 13 120 08 57	Azimuth Point	218 40 51	1455.1	1591.3	0.90
Monterey Bay	36 37 35.93	121 49 30.67	43 54 41 73 19 49	Rocky Point	300 08 04	2540.0	2777.6	1.58
Astronomical Station	36 37 59.29	121 54 25.00	306 10 54 275 35 55	Sand Hill	223 53 38	3771.8	4124.8	2.34
West Base	36 36 03.48	121 52 10.20	264 24 15 148 55 29	Rocky Point	253 17 54	5023.1	5493.2	3.12
Round Hill	36 33 49.89	121 51 27.97	202 41 43 161 02 40	Sand Hill	126 12 47	5820.8	6365.4	3.62
				Monterey Bay	95 38 51	7346.9	8034.4	4.56
				Sand Hill	84 24 47	1354.8	1481.6	0.84
				Rocky Point	328 55 09	1643.3	1797.1	1.02
				Monterey Bay	92 42 53	7552.2	8258.9	4.69
				Rocky Point	341 01 55	5841.7	6388.3	3.63

APPENDIX No. 16.

DISCUSSION OF THE MAGNETIC AND METEOROLOGICAL OBSERVATIONS MADE AT THE GIRARD COLLEGE OBSERVATORY, PHILADELPHIA, IN 1840, 1841, 1842, 1843, 1844, AND 1845. PART X.—ANALYSIS OF THE DISTURBANCES OF THE DIP AND TOTAL FORCE. BY A. D. BACHE, LL.D., PRESIDENT NATIONAL ACADEMY OF SCIENCES, SUPERINTENDENT UNITED STATES COAST SURVEY.

[From the Smithsonian Contributions to Knowledge.]

Analysis of the disturbances of the dip and total force.

In the preceding discussion of the disturbances of the horizontal and vertical components of the magnetic force at the Girard College observatory, the laws of their variations, as far as they have been recognizable from the series, were brought out and discussed, and this suffices, perhaps, in most cases, for any future application of theory, or for the purpose of testing hypotheses. But as it is also desirable for other comparisons to deduce the corresponding results for dip and total force from previous researches, it is proposed here to present the results of this combination numerically and in tabular form.

The combination is effected by the formulæ—

$$\Delta\theta = \sin\theta \cos\theta \left(\frac{\Delta Y}{Y} - \frac{\Delta X}{X} \right) \text{ and } \frac{\Delta\varphi}{\varphi} = \sin^2\theta \frac{\Delta Y}{Y} + \cos^2\theta \frac{\Delta X}{X},$$

which expressions have already been used in the preceding part.

A strict treatment of the disturbances of either the dip or total force would require the formation of the difference of each observation of the vertical and horizontal force from its normal value, (corresponding to the hour, month, and year,) the conversion of these differences from units of scale value into parts of the respective force, and, finally, the numerical combination of the contemporaneous values of the two instruments, by means of the above formulæ. To treat over 44,000 observations in this manner is impracticably laborious, and makes it desirable to substitute in its place another process less cumbrous, but, as regards results, equally effective. The method adopted avoids also the labor of forming normals, and especially that of separating the disturbances anew for each element. The method pursued in the discussion of the Toronto observations answer all purposes, and has been adopted for the Philadelphia series. A more distinct idea, however, is here given for the limiting value, beyond which disturbances are recognized. The method is as follows: Returning to the manuscript tables which contain the observations reduced to a uniform temperature and corrected for progressive change, as far as this was practicable, each observation marked there as a disturbance—that is, which differed as much or more than ± 30 scale divisions from the normal of the vertical force, and as much or more than ± 33 from the normal of the horizontal force—was transcribed, and at once converted into its equivalent in parts of the force to which it respectively belonged. One scale division of the vertical force magnetometer equals 0.000033 parts, and of the horizontal force magnetometer 0.0000365 parts, of the respective force. These disturbances of the two components were tabulated in chronological order; and when for any entry but one of the constituent parts appeared disturbed, the corresponding difference from the normal of the contemporaneous second part, whatever amount that might be, was likewise entered in an adjoining column. The corresponding values of $\Delta\theta$ and $\frac{\Delta\varphi}{\varphi}$ were then easily computed for each disturbance, whether it occurred in both components or in one only. Trustworthy contemporaneous readings of the two magnetometers commence with February, 1841, and continues to the close of the series, in June, 1845. There is, however, an interval of time between the readings of the instruments, which we are obliged to disregard—it amounts to but five minutes—the bifilar magnetometer having been read so much later.

As there is not generally a contemporaneous disturbance in the vertical and horizontal force, the total number of disturbed values obtained by the process explained above and employed is necessarily much greater than it was for either of the components. It becomes, therefore, necessary to fix upon some limit of recognition for a disturbed value of the dip and also of the total force. This is best done by the adoption of that value which will separate an equal proportion of disturbed values from the total number, as was done in the components. For the vertical component, one in every 10.5 observations; for the horizontal component, one in every 19.3 observations, was separated as a disturbed value between February 1, 1841, and June 30, 1845; on the average, therefore, one in every 15 observations should be separated in the dip and total force

series. During the time mentioned the number of observations of vertical force was 22,092, and of horizontal force 22,150, from which we should accordingly derive nearly 1,470 disturbances. Now the number of computed values of $\Delta\theta$ and of $\frac{\Delta\theta}{\varphi}$ is 2,362; hence, marking in each set the 1,470 highest values, the limit of ± 1.1 is reached in the dip and ± 0.00094 in the total force, which constitute the limiting values at and beyond which disturbances are recognized in each element. To render the series of disturbance results homogeneous, the disturbances at the odd hours after October, 1843, have been omitted. At Toronto the limit for the recognition of disturbances in the dip* was 1.0, and in the total force 0.0004, parts of the force.

Analysis of the disturbances of the inclination.

The number of values of inclination differing ± 1.1 or more from their normal amount, and which constitute the disturbance values, is 1,446. These are variously combined in the following tables, and, when necessary, are separated into two classes—those which increase and those which decrease the inclination. To the former the sign + is prefixed; to the latter the sign —. The aggregate and mean amount of disturbances are expressed in minutes of arc. The columns containing the number of disturbances are headed with the letter *n*. When ratios are given, they exhibit the proportion of the amount of disturbances during any given sub-period to the average amount of disturbances during the whole period. In the first and three subsequent tables the values for the first five months of 1841 are omitted, as there are no adequate means of extending the series beyond four full years.

TABLE I.—*Aggregate amount and number of disturbances of the inclination in each month, divided into disturbances, which increase and which decrease the inclination.*

Month.	1841 and 1842.				1842 and 1843.				1843 and 1844.			
	+	<i>n</i> .	—	<i>n</i> .	+	<i>n</i> .	—	<i>n</i> .	+	<i>n</i> .	—	<i>n</i> .
July	24.5	16	15.7	10	31.5	17	17.2	9	16.9	10	4.4	3
August	34.5	16	14.0	9	13.6	8	33.5	22	20.8	13	0.0	0
September	104.7	40	14.4	10	20.7	9	114.8	64	8.4	4	7.2	6
October	69.7	32	13.6	9	19.5	11	40.2	27	7.2	4	10.1	6
November	79.9	31	12.4	5	35.2	16	6.8	4	9.9	7	3.9	3
December	75.5	36	27.2	18	12.4	8	9.5	6	29.6	20	4.9	4
January	72.3	33	40.5	24	(50.7)	(27)	(23.2)	(14)	29.1	21	5.9	4
February	101.6	45	40.3	26	(57.6)	(26)	(22.2)	(14)	13.7	8	4.2	3
March	31.6	17	27.0	16	(37.5)	(20)	(18.6)	(12)	43.4	24	10.3	8
April	52.2	26	14.2	10	56.0	30	17.4	10	29.5	20	12.0	6
May	41.1	25	30.5	15	39.7	18	34.5	18	7.9	4	1.6	1
June	39.9	21	21.8	13	9.1	7	20.7	11	1.4	1	5.9	4

The values in parentheses for January, February and March are interpolated, and are the average values of the corresponding months of the year preceding and the year following.

Month.	1844 and 1845.				Sums, 1841 to 1845.				Ratio.	
	+	<i>n</i> .	—	<i>n</i> .	+	<i>n</i> .	—	<i>n</i> .	+	—
July	1.1	1	12.8	8	74.0	44	50.1	30	0.55	0.73
August	42.4	29	3.9	3	111.3	66	51.4	34	0.83	0.75
September	25.4	14	10.9	6	159.2	67	147.3	86	1.19	2.15
October	10.0	7	21.8	11	106.4	54	85.7	53	0.79	1.25
November	40.3	19	1.5	1	165.3	73	24.6	13	1.34	0.35
December	31.7	17	37.3	20	149.2	81	78.9	48	1.12	1.15
January	23.7	10	7.7	5	175.8	91	77.3	47	1.31	1.12
February	5.8	3	0.0	0	178.7	82	66.7	43	1.34	0.97
March	19.1	13	5.5	4	131.6	74	61.4	40	0.99	0.92
April	29.4	17	6.6	4	167.1	93	50.2	30	1.25	0.73
May	22.0	10	4.7	3	110.7	57	71.3	37	0.83	1.04
June	23.8	17	8.8	5	74.2	46	57.2	33	0.56	0.84

* Vol. iii, p. xliii.

It would appear that during the colder season both sets of ratios present greater values. Between September and February, inclusive, this ratio is on the average 1.16, and in the other months it is 0.84. Of the ratios decreasing the inclination, the September and November values are somewhat anomalous—the first too high, the second too low.

The following table gives the annual inequality of the disturbances, irrespective of their sign:

TABLE II.—*Aggregate amount and number of disturbances of the inclination in each month.*

	Sum.	n.	Ratio.
July.....	124.1	74	0.62
August.....	162.7	100	0.80
September.....	306.5	153	1.51
October.....	192.1	107	0.95
November.....	189.9	86	0.94
December.....	228.1	129	1.13
January.....	253.1	138	1.25
February.....	245.4	125	1.22
March.....	193.6	114	0.96
April.....	217.3	123	1.07
May.....	182.0	94	0.90
June.....	131.4	79	0.65

The series comprises the four years between July, 1841, and July, 1845. The ratio is that of the sums.

The ratio near the autumnal equinox is the greatest of all; that about the vernal equinox is a little below the average value. The least value occurs, probably, near the summer solstice.

TABLE III.—*Aggregate amount and number of disturbances of the inclination in the different years of observation.*

Year.	Sum.	n.	Ratio.
1841-'42.....	999.1	503	1.65
1842-'43.....	742.1	408	1.22
1843-'44.....	288.2	184	0.47
1844-'45.....	396.2	227	0.66

The ratios exhibit the variation due to the eleven-year inequality.

The minimum amount of disturbances in the eleven-year circle therefore occurred in the beginning of 1844.

TABLE IV.—*Aggregate amount and number of disturbances in each year, arranged for disturbances increasing the inclination and for those decreasing it, together with the ratios of the sums.*

Year.	Sum.	n.	Sum.	n.	Ratio.	
	+		—		+	—
1841-'42.....	727.5	338	271.6	165	1.81	1.32
1842-'43.....	383.5	197	358.6	211	0.96	1.74
1843-'44.....	217.8	136	70.4	48	0.55	0.35
1844-'45.....	274.7	157	121.5	70	0.68	0.59

The minimum of the eleven-year period is equally well marked in the disturbances increasing and in those decreasing the inclination. The sum of the positive values (1,603.5) is to the sum of the negative values, (822.1,) as 1.95 to 1. At Toronto, between 1844 and 1848, this ratio was 5.6 to 1. The ratio, however, increased from 2.7 to 8.5 to 1 during this time.

In Tables V and VI, which exhibit the diurnal inequality of the disturbances, the whole series between February, 1841, and June, 1845, is employed. The sums, numbers, and ratios given do not in strictness apply to the even hours, but to an epoch 20 minutes later.

TABLE V.—*Aggregate amount and number of disturbances of the inclination, distributed over the even hours of the day, and ratio, showing the diurnal inequality of the sun.*

Hour.	Sum.	n.	Ratio.
0.....	244.8	143	1.11
2.....	183.2	110	0.83
4.....	184.1	111	0.84
6.....	170.8	98	0.78
8.....	154.8	94	0.70
10.....	213.6	116	0.99
Noon.....	250.7	141	1.14
14.....	260.9	131	1.19
16.....	232.4	130	1.06
18.....	245.0	126	1.11
20.....	253.6	121	1.16
22.....	238.0	125	1.09

The hourly disturbances of the inclination exhibit a regular progression—between 1 a. m. and 11 a. m. the numbers fall short of the mean hourly value, and during the remaining afternoon and night hours they exceed this average value. The minimum occurs near 8 a. m., and the maximum near 8 p. m. There is, however, an indication of a superimposed smaller progression, which, owing to the short series of observation, is not distinctly brought out. At Toronto we have a double progression, and the above ratios approximate to it. At Philadelphia a secondary maximum probably occurs about noon, and a secondary minimum about 4 p. m.

Table VI shows the ratios at the different hours for disturbances increasing and disturbances decreasing the inclination.

TABLE VI.—*Aggregate amount and number of hourly disturbances of the inclination for increasing and decreasing values, and mean effect of disturbances.*

Hour.	Sum.	n.	Sum.	n.	Ratio of sum.		Excess of increasing disturbances.	Average diurnal effect of disturbances.
	+		—		+	—		
0.....	163.9	94	80.9	49	1.15	1.06	+ 83.0	+ 0.06
2.....	101.7	61	81.5	49	0.71	1.06	+ 20.2	+ 0.02
4.....	82.4	51	101.7	60	0.58	1.33	— 19.3	— 0.02
6.....	97.1	57	73.7	41	0.68	0.96	+ 23.4	+ 0.02
8.....	97.8	58	57.0	36	0.60	0.74	+ 40.8	+ 0.03
10.....	130.2	64	83.4	52	0.91	1.09	+ 46.8	+ 0.04
Noon.....	139.3	75	111.4	66	0.98	1.45	+ 27.9	+ 0.02
14.....	193.2	90	67.7	41	1.35	0.89	+ 125.5	+ 0.10
16.....	148.5	79	83.9	51	1.04	1.09	+ 64.6	+ 0.05
18.....	178.7	86	66.3	40	1.25	0.87	+ 112.4	+ 0.09
20.....	198.3	87	55.3	34	1.39	0.72	+ 143.0	+ 0.11
22.....	181.5	91	56.5	34	1.27	0.74	+ 125.0	+ 0.10

The disturbances which increase the inclination show a very regular single progression, the value at 2 p. m. only being slightly anomalous; their minimum occurs at 4 a. m., and their maximum at 8 p. m. The disturbances decreasing the inclination are small in number at all hours, and show a tendency at double progression—principal maximum about noon, principal minimum about 8 p. m., secondary maximum about 4 a. m., and secondary minimum about 8 a. m. At Toronto the results appear different; but it is absolutely necessary for effective comparison to have results from contemporaneous series. As at Toronto, the disturbances increasing the inclination greatly preponderate over those decreasing it. The accumulated effect of this difference is shown in the column headed "excess," (Table VI.) At the hour 4 a. m. alone we find the increasing disturbances inferior; at the hour 8 p. m. the difference has reached its maximum. At Toronto this maximum occurred an hour or two after midnight. The last column of Table VI exhibits the average diurnal effect of the disturbances, (exceeding $1'$, their normal value,) the plus sign indicating a preponderance of increasing dip. The number of days is 1,297.

The distribution of the disturbances according to their magnitude, for an equal increase of $1'$, is as follows:

Between	No. of disturbances.
1.1 and 2.1	1096
2.1 and 3.1	247
3.1 and 4.1	65
4.1 and 5.1	27
5.1 and 6.1	5
6.1 and 7.1	3
7.1 and 8.1	3
Beyond	None.

Analysis of the disturbances of the total force.

The number of values of total force differing 0.00094 parts of the force from its normal amount, and which constitute the disturbance values, is 1,470, which have been combined in a manner similar to that of the disturbances of the dip. An increasing total force is indicated by a + sign; a decreasing one by a — sign. The aggregate amount and mean amount of disturbances are expressed in parts of the force, and the letter *n* indicates the number of disturbances. In the tables of the annual inequality the series commences with July, 1841; in those of the diurnal inequality it commences with February, 1841. The ratios given are those of the aggregate amount.

TABLE VII.—*Aggregate amount and number of disturbances of the total force in each month, divided into disturbances which increase and which decrease the force.*

Month.	1841 and 1842.				1842 and 1843.				1843 and 1844.			
	+	n.	—	n.	+	n.	—	n.	+	n.	—	n.
July .....	.02944	25	.04552	32	.01115	8	.02518	15	.00000	0	.00377	3
August .....	.01239	10	.00438	4	.00758	5	.02658	24	.00830	8	.00200	2
September .....	.01759	15	.02807	19	.02395	16	.06228	42	.01355	10	.00734	7
October .....	.02658	20	.00297	6	.01148	10	.00410	4	.00663	5	.00585	5
November .....	.02357	17	.02413	20	.00781	6	.00960	9	.01563	13	.02485	21
December .....	.07398	47	.05026	35	.00715	7	.00898	7	.03267	28	.00645	6
January .....	.06321	38	.04939	36	(.04792)	(32)	(.03222)	(24)	.03264	27	.01506	13
February .....	.07043	50	.03481	28	(.04151)	(30)	(.01984)	(16)	.01250	10	.00486	4
March .....	.01895	15	.02730	19	(.02711)	(22)	(.02574)	(19)	.03527	29	.02419	19
April .....	.04122	28	.02820	19	.03523	24	.02084	18	.02181	19	.01940	1
May .....	.04526	27	.02443	16	.02897	17	.01736	14	.00977	6	.00000	0
June .....	.02777	21	.01191	11	.00561	3	.01038	7	.00342	3	.02193	20

The values in parentheses for January, February, and March, are interpolated, and are the average values of the corresponding months of the year preceding and the year following.

Month.	1844 and 1845.				Sums, 1841—1845.				Ratio.	
	+	n.	—	n.	+	n.	—	n.	+	—
July.....	.00805	8	.01076	9	.04864	41	.08523	59	0.56	1.28
August.....	.04661	35	.01348	10	.07488	58	.04644	40	0.87	0.70
September.....	.00715	5	.00108	1	.06224	46	.00877	69	0.72	1.48
October.....	.00331	3	.00809	5	.04800	38	.02501	20	0.56	0.38
November.....	.00000	0	.00100	1	.04701	36	.03058	51	0.54	0.89
December.....	.01365	12	.00416	4	.12945	94	.06885	52	1.50	1.05
January.....	.00210	2	.00543	4	.14587	99	.10210	77	1.68	1.53
February.....	.00000	0	.00216	2	.12453	90	.06167	50	1.44	0.92
March.....	.02489	20	.01231	11	.10622	86	.08954	68	1.23	1.34
April.....	.00513	4	.00463	3	.10339	75	.07307	54	1.20	1.10
May.....	.02511	12	.00211	2	.10771	62	.04390	32	1.24	0.65
June.....	.00270	2	.00108	1	.03950	29	.04530	39	0.46	0.68

The ratios of the increasing disturbances of the force have a double progression, as have also those of the decreasing disturbances, though not so well marked. Increasing disturbances show a principal maximum in January, a principal minimum in June, and a secondary maximum and minimum in August and November, respectively. Decreasing disturbances show a principal maximum in January, a principal minimum in October, and a secondary maximum and minimum in September and May, respectively. It appears, therefore, that, upon the whole, we observe the same laws as at Toronto, viz: the disturbances increasing the force and those decreasing the force follow the same progressive monthly change, and exhibit maximum values about the equinoxes and minimum values about the solstices. This last remark also applies to the results of the following table, in which the annual inequality of the disturbances is given, irrespective of sign.

TABLE VIII.—Aggregate amount and number of disturbances of the total force in each month, and ratio of sums.

	Sum.	n.	Ratio.
July.....	0.13387	100	0.87
August.....	0.12132	98	0.79
September.....	0.16101	115	1.05
October.....	0.07301	58	0.47
November.....	0.10659	87	0.70
December.....	0.19930	146	1.30
January.....	0.24797	176	1.62
February.....	0.18620	140	1.22
March.....	0.19576	154	1.28
April.....	0.17646	129	1.15
May.....	0.15161	94	0.99
June.....	0.08480	68	0.56

TABLE IX.—Aggregate amount and number of disturbances of the total force in the different years of observation.

Year.	Sum.	n.	Ratio.
1841-'42.....	.78836	558	1.72
1842-'43.....	.51657	379	1.13
1843-'44.....	.32798	272	0.71
1844-'45.....	.20499	156	0.44

The ratios of the sums exhibit part of the eleven year inequality.

The minimum of the eleven-year period, according to the above ratio, occurred, probably, in 1845.

TABLE X.—*Aggregate amount and number of disturbances in each year (July to July) arranged for disturbances increasing and disturbances decreasing the force, with ratios of sums.*

Year.	Sum.	n.	Sum.	n.	Ratio.	
	+		—		+	—
1841-'42 .....	.45299	313	.33537	245	1.75	1.67
1842-'43 .....	.25347	180	.26310	199	0.98	1.32
1843-'44 .....	.19228	158	.13570	114	0.74	0.68
1844-'45 .....	.13870	103	.06629	53	0.53	0.33

The inequality of the eleven-year period is equally well marked for disturbances increasing and for disturbances decreasing the total force. The sum of the positive values is 1.03744, and of the negative value, 0.80046. Increasing disturbances are, therefore, preponderating in the ratio of 1.3 to 1. In the years 1842-'43, however, decreasing disturbances were in excess over increasing ones; and at Toronto, between 1844 and 1848, the general effect of the larger disturbances of the force was to decrease the total magnetic force more than to increase it. The excess in the different years appears to be rather irregular.

The following tables exhibit the diurnal inequality of the disturbances. The whole series, beginning with February, 1841, is employed. The sums, numbers, and ratios given apply to an epoch 20 minutes later than indicated by the tables.

TABLE XI.—*Aggregate amount and number of disturbances of the total force, distributed over the even hours of the day, and ratio showing the diurnal inequality of the sum.*

Hour.	Sum.	n.	Ratio.
0.....	.19733	150	1.19
2.....	.20046	148	1.22
4.....	.20018	148	1.21
6.....	.17163	121	1.04
8.....	.13858	106	0.84
10.....	.13691	105	0.83
Noon.....	.15058	115	0.92
14.....	.19949	144	1.21
16.....	.14958	116	0.91
18.....	.13974	103	0.85
20.....	.13176	97	0.80
22.....	.16077	117	0.98

The hourly disturbances exhibit a regular double progression, with a principal maximum at 2 a. m. and a principal minimum at 8 p. m.; also a secondary maximum about 2 p. m. and a secondary minimum about 10 a. m. At Toronto these hours were, respectively, 3 a. m., 11 a. m., and 5 p. m., 9 p. m., showing an exchange of the hours of the principal and secondary minimum. The disturbance at the hour of maximum is about eleven times greater than at the minimum hour; whereas this proportion is but one and a half to one at Philadelphia.

TABLE XII.—*Aggregate amount and number of hourly disturbances of the total force for increasing and decreasing values, ratios, and mean effect of disturbances.*

Hour.	Sum.	n.	Sum.	n.	Ratio of sum.		Difference of sums.	Average diurnal effect.
	+		—		+	—		
0.....	.10370	83	.09163	67	1.22	1.18	+ .01407	+ .000011
2.....	.08589	68	.11457	80	0.99	1.47	— .03868	— .000022
4.....	.08364	66	.11754	82	0.95	1.51	— .03490	— .000027
6.....	.08449	57	.08714	64	0.97	1.12	— .00265	— .000002
8.....	.06261	48	.07597	58	0.72	0.97	— .01336	— .000010
10.....	.06364	46	.07327	59	0.73	0.94	— .00963	— .000008
Noon.....	.07094	51	.07964	64	0.82	1.02	— .00870	— .000007
14.....	.13083	86	.06866	58	1.50	0.88	+ .06217	+ .000049
16.....	.08664	66	.06394	50	1.00	0.81	+ .02370	+ .000018
18.....	.08880	64	.05094	39	1.02	0.66	+ .03786	+ .000029
20.....	.08223	60	.04953	37	0.95	0.64	+ .03270	+ .000025
22.....	.08791	71	.06286	46	1.13	0.80	+ .03505	+ .000027

The ratios of the increasing and decreasing disturbances appear to follow the same law—that is, the values at any hour appear to be complementary to one another, a high plus value corresponding to a low minus value. The phenomenon is, however, not so distinctly brought out as from the longer series at Toronto. The last two columns contain the differences of the sums at each hour, and the average effect of the larger disturbances of the total force. From 1 p. m. to 1 a. m. the larger disturbances augment the total force; from 1 a. m. to 1 p. m. they diminish it. Greatest augmentation at 2 p. m.; greatest diminution at 4 a. m. The greatest augmentation is nearly twice as great as the greatest diminution; whereas, at Toronto the opposite effect was observed.

The distribution of the disturbances of the total force according to their magnitude, for an equal increase of .00090 parts of the force, is as follows:

Between	No. of disturbances.
.00094 and .00184.....	1324
.00184 and .00274.....	122
.00274 and .00364.....	17
.00364 and .00454.....	4
.00454 and .00544.....	2
.00544 and .00634.....	0
.00634 and .00724.....	1
Beyond.....	None.

APPENDIX No. 17.

DISCUSSION OF THE MAGNETIC AND METEOROLOGICAL OBSERVATIONS MADE AT THE GIRARD COLLEGE OBSERVATORY, PHILADELPHIA, IN 1840, 1841, 1842, 1843, 1844, AND 1845. PART XI.—SOLAR-DIURNAL VARIATION AND ANNUAL INEQUALITY OF THE INCLINATION AND TOTAL FORCE, WITH DIAGRAMS, (SEE PLATE No. 38.) BY A. D. BACHE, LL.D., PRESIDENT NATIONAL ACADEMY OF SCIENCES, SUPERINTENDENT UNITED STATES COAST SURVEY.

[From the Smithsonian Contributions to Knowledge.]

Solar-diurnal variation of the dip and total force.

To make the combination of the horizontal and vertical-force components complete, there remains the discussion of the regular solar-diurnal variation and its annual inequality of the resulting dip and total force.

Table III, of Part V, contains the solar-diurnal variation, expressed in parts of the force, of the horizontal component freed from the larger disturbances. Table III, of Part VIII, contains similar information with regard to the vertical component. The numbers of these tables, however, cannot be combined directly, owing to the eleven-year inequality, which requires that the two sets of components should cover precisely the same interval of time. In the present case the table of the horizontal force extends from July, 1840, to July, 1845, a five-year series; whereas the table of the vertical force extends over four years only. A new table of monthly normals of the horizontal component was therefore prepared, in which the first year's observations were omitted. This was done by the same method as had been followed in the preparation of the former annual values of Part V. The following table differs from that of Table I, of Part V, only in the number of observations employed, and extends from July, 1841, to July, 1845:

TABLE I.—*Recapitulation of the hourly normals of the horizontal force (expressed in scale divisions) for each month of the year, and for summer, winter, and the whole year, between July, 1841, and July, 1845.*

1841—45.	0h.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11h.	+ 21 $\frac{1}{2}$ m.
July	791	790	789	788	787	786	785	788	796	803	806	804	.....
August	813	813	813	812	811	809	808	815	825	835	837	830	.....
September	829	827	830	829	826	824	821	830	842	850	853	852	.....
October	850	846	847	845	844	844	844	848	854	860	865	864	.....
November	853	852	850	849	848	846	845	849	853	859	862	865	.....
December	883	879	878	877	874	873	871	872	874	878	883	892	.....
January	905	902	902	901	899	899	899	898	900	908	914	918	.....
February	915	914	913	912	910	908	906	908	910	914	920	922	.....
March	919	917	915	915	915	913	912	915	920	927	931	936	.....
April	945	944	944	942	940	938	938	940	948	958	965	966	.....
May	947	946	944	942	942	940	938	944	954	961	960	956	.....
June	972	972	972	972	969	966	962	968	973	980	983	980	.....
Year	885.2	883.5	883.1	882.0	880.4	878.8	877.4	881.2	887.4	894.4	898.4	898.8	.....
Summer	882.8	882.0	882.0	880.8	879.2	877.2	875.3	880.8	889.7	897.8	900.7	898.0	.....
Winter	887.5	885.0	884.2	883.2	881.7	880.5	879.5	881.7	885.2	891.0	896.2	899.5	.....

The summer months comprise April to September, inclusive; the winter months comprise October to March, inclusive. One scale division equals 0.0000365 parts of the force. Increasing numbers denote decrease of force.

1841-'45.	12h. (noon.)	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23h.	+ 24h.
July	797	788	782	780	779	783	788	791	793	793	793	793	.....
August	820	811	803	802	804	809	815	816	817	816	816	815	.....
September	844	834	829	828	828	832	834	834	832	834	832	832	.....
October	866	860	856	854	854	854	854	854	855	853	853	852	.....
November	861	858	853	852	851	853	851	851	852	852	853	853	.....
December	894	889	885	880	878	878	879	880	882	884	884	883	.....
January	916	909	905	900	890	902	905	905	904	905	905	904	.....
February	925	920	915	912	915	915	916	919	921	917	915	915	.....
March	934	930	923	918	921	923	924	923	921	920	921	920	.....
April	960	957	947	944	943	944	948	948	949	950	947	947	.....
May	951	943	938	938	938	939	945	947	949	949	948	945	.....
June	974	969	962	961	961	965	970	971	971	972	973	973	.....
Year	895.2	889.0	883.2	880.7	880.9	883.1	885.7	886.5	887.2	887.1	886.7	886.0	.....
Summer	891.0	883.7	876.8	875.5	875.5	878.7	883.3	884.5	888.2	885.7	884.8	884.2	.....
Winter	899.3	894.0	889.5	886.0	886.3	887.5	888.2	888.7	889.2	888.5	888.5	887.8	.....

Subtracting each value from its respective monthly mean value, and converting these differences into parts of the force, we obtain the numbers of Table II; a plus sign indicates a greater force than the normal value, a minus sign a smaller one. The first three decimals are placed at the head of the table.

TABLE II.—Regular solar-diurnal variation of the horizontal force between Ju'y 1841 and July 1845

Values of $\frac{\Delta X}{X}$.

0.000

1841-'45.	0h.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11h.	+ 24h.
January	-.025	+.085	+.085	+.121	+.194	+.194	+.194	+.231	+.158	-.134	-.353	-.499	.....
February	-.005	+.032	+.068	+.105	+.178	+.251	+.324	+.251	+.178	+.032	-.186	-.259	.....
March	+.087	+.160	+.233	+.233	+.233	+.306	+.342	+.233	+.050	-.205	-.351	-.534	.....
April	+.110	+.146	+.146	+.219	+.292	+.365	+.365	+.292	000	-.365	-.620	-.657	.....
May	-.036	000	+.073	+.146	+.146	+.219	+.292	+.073	-.292	-.547	-.511	-.365	.....
June	-.056	-.056	-.056	-.056	+.054	+.163	+.309	+.090	-.092	-.348	-.457	-.348	.....
July	-.017	+.019	+.056	+.092	+.129	+.165	+.202	+.092	-.200	-.455	-.565	-.492	.....
August	+.020	+.020	+.020	+.117	+.153	+.226	+.263	+.007	-.358	-.723	-.796	-.540	.....
September	+.168	+.241	+.131	+.168	+.277	+.350	+.460	+.131	-.307	-.569	-.708	-.672	.....
October	+.116	+.262	+.225	+.298	+.335	+.335	+.335	+.189	-.030	-.249	-.435	-.395	.....
November	000	+.035	+.109	+.145	+.181	+.256	+.291	+.145	000	-.220	-.329	-.439	.....
December	-.091	+.055	+.091	+.128	+.237	+.274	+.347	+.310	+.237	+.091	-.164	-.420	.....
Year	+.027	+.088	+.103	+.143	+.201	+.259	+.310	+.171	-.055	-.310	-.456	-.469	.....
Summer	+.043	+.072	+.072	+.116	+.174	+.247	+.317	+.116	-.209	-.505	-.610	-.512	.....
Winter	+.014	+.105	+.134	+.171	+.226	+.269	+.305	+.225	+.098	-.114	-.303	-.424	.....

1841-'45.	12h. (noon.)	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23h.	+ 24h.
January	-.427	-.171	-.025	+.158	+.194	-.085	-.025	-.025	+.011	-.025	-.025	+.012	.....
February	-.370	-.186	-.005	+.105	-.005	-.005	-.042	-.151	-.224	-.078	-.005	-.005	.....
March	-.461	-.315	-.059	+.123	+.014	-.059	-.096	-.059	+.014	+.050	+.014	+.050	.....
April	-.438	-.328	+.036	+.146	+.182	+.146	000	000	-.036	-.073	+.036	+.036	.....
May	-.182	+.109	+.292	+.292	+.292	+.256	+.036	-.036	-.109	-.109	-.073	+.036	.....
June	-.129	+.054	+.309	+.346	+.346	+.200	+.017	-.019	-.019	-.056	-.092	-.092	.....
July	-.236	+.092	+.311	+.384	+.421	+.275	+.092	-.017	-.090	-.090	-.090	-.090	.....
August	-.175	+.153	+.445	+.482	+.409	+.226	+.007	-.029	-.066	-.029	-.029	+.007	.....
September	-.380	-.015	+.168	+.204	+.204	+.058	-.015	-.015	+.058	-.015	+.058	+.058	.....
October	-.468	-.249	-.103	-.030	-.030	-.030	-.030	-.067	+.006	+.006	+.006	+.043	.....
November	-.293	-.183	000	+.035	+.072	000	+.072	+.072	+.035	+.035	000	000	.....
December	-.493	-.310	-.164	+.018	+.091	+.091	+.055	+.018	-.055	-.128	-.128	-.091	.....
Year	-.338	-.112	+.100	+.189	+.183	+.103	+.006	-.023	-.046	-.043	-.028	-.003	.....
Summer	-.257	+.011	+.262	+.309	+.309	+.192	+.025	-.019	-.044	-.063	-.030	-.008	.....
Winter	-.416	-.236	-.059	+.062	+.057	+.014	-.012	-.030	-.048	-.023	-.023	+.004	.....

To render the preceding table uniform with the similar one of the vertical component, the values at the odd hours will hereafter be dropped. Their weight is less than one-half of that of the even hours. The small difference in the times (0.^m9) will be disregarded, and the values of the dip and total force, immediately deduced from the horizontal and vertical components, will refer to an epoch 21.^m1 after the full hour.

For greater completeness Table III, of Part VIII, is here inserted.

TABLE III.—*Regular solar-diurnal variation of the vertical force between July, 1841, and July, 1845.*

Values of $\frac{\Delta Y}{Y}$.

1841 to 1845.	0h.	2.	4.	6.	8.	10.	Noon.	14.	16.	18.	20.	22h.	$\frac{m}{+20.6}$.
January	— 059	+ 238	+ 040	— 026	— 026	+ 172	+ 172	+ 304	— 092	— 323	— 224	— 158	.....
February	— 198	+ 033	— 132	— 165	+ 009	+ 231	+ 264	+ 396	+ 198	— 264	— 330	— 132	.....
March	— 178	+ 085	— 046	— 112	+ 086	+ 119	+ 251	+ 317	+ 020	— 178	— 145	— 211	.....
April	— 353	— 155	— 122	— 023	+ 175	+ 274	+ 274	+ 340	+ 241	— 023	— 320	— 320	.....
May	— 412	— 346	— 214	+ 049	+ 247	+ 280	+ 346	+ 445	+ 313	+ 016	— 373	— 412	.....
June	— 528	— 297	— 198	— 033	+ 198	+ 396	+ 594	+ 462	+ 363	— 066	— 429	— 462	.....
July	— 571	— 406	— 241	+ 056	+ 221	+ 419	+ 584	+ 551	+ 386	— 043	— 406	— 538	.....
August	— 485	— 386	— 287	— 089	+ 109	+ 406	+ 736	+ 571	+ 340	— 023	— 386	— 485	.....
September	— 469	— 304	— 271	— 205	+ 092	+ 323	+ 521	+ 521	+ 356	+ 026	— 271	— 337	.....
October	— 099	+ 066	000	— 009	+ 231	+ 198	+ 198	+ 198	— 033	— 198	— 264	— 198	.....
November	— 043	— 043	— 142	— 109	+ 086	+ 122	+ 254	+ 221	— 010	— 076	— 109	— 169	.....
December	— 059	+ 139	+ 040	— 059	+ 040	+ 139	+ 265	+ 265	— 092	— 290	— 191	— 125	.....
Year	— 287	— 115	— 131	— 068	+ 129	+ 257	+ 366	+ 377	+ 165	— 121	— 222	— 290	.....
Summer	— 469	— 317	— 221	— 040	+ 175	+ 350	+ 508	+ 482	+ 333	— 020	— 353	— 426	.....
Winter	— 106	+ 086	— 040	— 096	+ 082	+ 162	+ 224	+ 274	000	— 221	— 211	— 155	.....

Solar-diurnal variation of the inclination.

The combination of the component values $\frac{\Delta X}{X}$ and $\frac{\Delta Y}{Y}$ to form the corresponding values of the dip is effected by the formula $\Delta\theta = \sin \theta \cos \theta \left(\frac{\Delta Y}{Y} - \frac{\Delta X}{X} \right)$.

$\Delta\theta$ will be expressed in minutes. $\theta = 71^\circ 59'$. A plus sign indicates an augmentation of the north dip; a minus sign the converse.

TABLE IV.—*Regular solar diurnal variation of the dip between July, 1841, and July, 1845. Values of $\Delta\theta$.*

1841 to 1845.	0h.	2.	4.	6.	8.	10.	Noon.	14.	16.	18.	20.	22h.	$\frac{m}{+21.1}$.
January	—0.03	+0.15	—0.16	—0.22	—0.19	+0.53	+0.61	+0.33	—0.30	—0.31	—0.24	—0.13	.....
February	—0.20	—0.04	—0.32	—0.50	—0.08	+0.42	+0.63	+0.40	+0.20	—0.22	—0.11	—0.13	.....
March	—0.27	—0.15	—0.28	—0.46	+0.04	+0.48	+0.72	+0.38	+0.01	—0.08	—0.16	—0.23	.....
April	—0.47	—0.30	—0.41	—0.39	+0.18	+0.91	+0.73	+0.31	+0.06	—0.02	—0.28	—0.36	.....
May	—0.38	—0.43	—0.37	—0.25	+0.54	+0.80	+0.53	+0.15	+0.02	—0.02	—0.30	—0.34	.....
June	—0.47	—0.24	—0.25	—0.34	+0.30	+0.87	+0.75	+0.16	+0.02	—0.08	—0.40	—0.37	.....
July	—0.56	—0.46	—0.37	—0.15	+0.43	+1.00	+0.83	+0.24	—0.04	—0.14	—0.32	—0.45	.....
August	—0.57	—0.47	—0.44	—0.35	+0.47	+1.22	+0.92	+0.13	—0.07	—0.03	—0.32	—0.46	.....
September	—0.63	—0.43	—0.54	—0.63	+0.41	+1.05	+0.92	+0.36	+0.15	+0.04	—0.33	—0.39	.....
October	—0.23	—0.17	—0.35	—0.45	+0.25	+0.64	+0.67	+0.30	—0.02	—0.18	—0.21	—0.22	.....
November	—0.04	—0.15	—0.32	—0.40	+0.09	+0.47	+0.56	+0.22	—0.08	—0.15	—0.14	—0.11	.....
December	+0.03	+0.05	—0.20	—0.41	—0.20	+0.30	+0.71	+0.37	—0.18	—0.35	—0.14	0.00	.....
Year	—0.32	—0.22	—0.33	—0.38	+0.19	+0.72	+0.71	+0.28	—0.02	—0.13	—0.24	—0.27	.....
Summer	—0.51	—0.39	—0.40	—0.36	+0.39	+0.98	+0.78	+0.22	+0.02	—0.04	—0.31	—0.40	.....
Winter	—0.12	—0.05	—0.27	—0.41	—0.01	+0.47	+0.65	+0.33	—0.06	—0.22	—0.17	—0.14	.....

Annual inequality in the diurnal variation of the dip.

The comparison of the above diurnal variations for summer and winter with that of the whole year is given in the following Table V :

	0h.	2.	4.	6.	8.	10.	Noon.	14.	16.	18.	20.	22h.	^{m.} +21.1.
Summer	-0.19	-0.17	-0.07	+0.02	+0.20	+0.26	+0.07	-0.06	+0.04	+0.09	-0.07	-0.13	.....
Winter	+0.20	+0.17	-0.06	-0.03	-0.20	-0.25	-0.06	+0.05	-0.04	-0.09	+0.07	+0.13	.....

These tabular values are exhibited in diagram A. The diagram shows the hours of no semi-annual change as follows : 5½ a. m., 1 p. m., 3 p. m., and 7 p. m. Greatest change at 10 a. m. ; secondary at 6 p. m., with a range of 0.51 and 0.18, respectively.

The turning epochs are found by the variations at the hour 10 a. m., when the monthly differences from the annual mean are as follows :

January	- 0.19	July.....	+ 0.28
February	- 0.30	August	+ 0.50
March	- 0.24	September	+ 0.33
April	+ 0.19	October	- 0.08
May	+ 0.08	November.....	- 0.25
June	+ 0.15	December.....	- 0.42

These values are represented by the formula,

$$\Delta_a = 0.35 \sin (\theta + 253^\circ 38') + 0.10 \sin (2\theta + 328^\circ 39'),$$

the angle θ counting from January 1. This formula gives a change of sign for the middle of April and the middle of October, or about 25 days after the equinoxes.

Analysis of the solar-diurnal variation of the dip.

The solar-diurnal variation has also been expressed by Bessel's periodic function for each month, summer, winter, and year. The angle θ counts from midnight, at the rate of 15° an hour; a positive sign indicates increase of north dip; a negative sign the reverse. The expressions are derived directly from Table IV. Diagram B exhibits the observed and computed diurnal variation for the summer months, and diagram C for the winter months. Diagram D exhibits the diurnal variation of the dip for summer, winter, and the whole year.

The general character of the three curves (diagram D) is the same; the annual curve has its greatest value about 11 a. m., and its least value about 5 a. m., with a range of about 1.2. In summer the epochs occur a little earlier, with a range of about 1.5; in winter the epochs are a little later, and the range is contracted to about 1.0. There is also a secondary maximum between 1 and 2 a. m., with a less regular secondary minimum occurring at some hour in the afternoon, or early in the night. In summer, however, these minima appear interchanged.

The Toronto curves are similar to those shown on diagram D. The shifting of the epochs is the same as at Philadelphia. The morning minimum is less prominent, and the afternoon minimum constitutes the principal minimum during summer, and also, on the average, during the year. The total annual range is almost exactly the same at the two places, and the times of the principal maxima also nearly coincide.

The following table contains the computed times of the principal maximum and of the morning minimum; also the elapsed time, together with the amount and range for each month and season; also the times, and amount, and range of the afternoon or early night minimum, taken from the diagrams :

TABLE VI.

1841 to 1845.	Principal maximum at—	Amount in minutes.	A. M. minimum at—	Amount in minutes.	Elapsed time between maximum and minimum.	A. M. range.	Afternoon minimum about—	Early night minimum about—	Range of afternoon minimum and principal maximum.
	<i>h. m.</i>	<i>'</i>	<i>h. m.</i>	<i>'</i>	<i>h. m.</i>	<i>'</i>	<i>h.</i>	<i>h.</i>	<i>'</i>
January.....	11 59	+ 0.69	6 39	— 0.32	5 20	1.01	6	—	1.0
February.....	12 15	+ 0.67	6 04	— 0.48	6 11	1.15	8	—	0.9
March.....	11 57	+ 0.72	5 54	— 0.43	6 03	1.15	—	11	—
April.....	11 11	+ 0.92	5 11	— 0.48	6 00	1.40	—	10	—
May.....	10 24	+ 0.81	4 07	— 0.46	6 17	1.27	—	11	—
June.....	11 01	+ 0.91	5 16	— 0.36	5 45	1.27	5	10	1.0
July.....	10 57	+ 1.00	*3 15	— 0.43	7 42	1.43	5	11	1.1
August.....	10 49	+ 1.21	4 45	— 0.53	6 04	1.74	4	11	1.3
September.....	10 56	+ 1.10	4 57	— 0.69	5 59	1.79	—	10	—
October.....	11 25	+ 0.73	5 17	— 0.49	6 08	1.22	—	10	—
November.....	11 29	+ 0.60	5 28	— 0.40	6 01	1.00	6	—	0.7
December.....	12 24	+ 0.69	6 43	— 0.41	5 39	1.10	6	—	1.0
Summer.....	10 55	+ 1.00	4 45	— 0.48	6 10	1.42	—	—	—
Winter.....	11 55	+ 0.67	6 00	— 0.39	5 55	1.06	—	—	—
Year.....	11 22	+ 0.81	5 18	— 0.40	6 04	1.21	—	—	—

* About 3½ a. m.; minimum not distinctly marked.

The diurnal range is greater about the time of the equinoxes than at any other time, and, in general, less in winter and greater in summer. The afternoon minimum disappears about the time of the equinoxes, and is best marked about the solstices. The early night minimum only disappears about the time of the winter solstice.

TABLE VII.—Principal epochs of normal dip.

1841 to 1845.	A. M.	P. M.
	<i>h. m.</i>	<i>h.</i>
January.....	8 38	3½
February.....	8 49	5
March.....	8 35	5
April.....	7 46	5½
May.....	6 52	5½
June.....	7 11	3½
July.....	6 55	3½
August.....	7 16	3
September.....	7 37	6½
October.....	8 03	5
November.....	8 10	3½
December.....	9 14	3½
Summer.....	7 22	4
Winter.....	8 33	3½
Year.....	7 50	2½

The morning epoch is computed to the nearest minute or two; the afternoon epoch is taken from the diagrams.

Solar-diurnal variation of the total force.

The combination of the component values of $\frac{\Delta X}{X}$ and $\frac{\Delta Y}{Y}$ to form the corresponding values of the total force is effected by the formula—

$$\frac{\Delta \phi}{\phi} = \sin 2\theta \frac{\Delta Y}{Y} + \cos 2\theta \frac{\Delta X}{X},$$

the result being expressed in parts of the force. A plus sign indicates an augmentation of the force; a minus sign a diminution.

TABLE VIII.—*Regular solar-diurnal variation of the total force between July, 1841, and July, 1845.*

Values of $\frac{\Delta \phi}{\phi}$ to six places of decimals; the first three are placed outside the table.

0.000.

1841 to 1845.	0h.	2.	4.	6.	8.	10.	Noon.	14.	16.	18.	20.	22h.	m. 21.1.
January.....	— 056	+ 224	+ 055	— 004	— 007	+ 122	+ 115	+ 273	— 064	— 294	— 202	— 144	.....
February.....	— 178	+ 038	— 100	— 115	+ 108	+ 190	+ 193	+ 358	+ 178	— 241	— 319	— 119	.....
March.....	— 152	+ 099	— 019	— 068	+ 082	+ 072	+ 183	+ 280	+ 019	— 169	— 130	— 189	.....
April.....	— 308	— 126	— 081	+ 015	+ 158	+ 188	+ 205	+ 311	+ 236	— 021	— 292	— 286	.....
May.....	— 375	— 305	— 179	+ 073	+ 194	+ 203	+ 294	+ 431	+ 312	+ 017	— 294	— 379	.....
June.....	— 483	— 274	— 175	— 001	+ 169	+ 312	+ 523	+ 447	+ 362	— 058	— 391	— 428	.....
July.....	— 519	— 363	— 206	+ 069	+ 182	+ 323	+ 504	+ 527	+ 387	— 031	— 377	— 496	.....
August.....	— 433	— 343	— 246	— 056	+ 062	+ 289	+ 646	+ 557	+ 345	— 022	— 357	— 444	.....
September.....	— 408	— 263	— 218	— 142	+ 054	+ 226	+ 436	+ 488	+ 343	+ 022	— 240	— 299	.....
October.....	— 077	+ 082	+ 033	— 056	+ 208	+ 138	+ 135	+ 169	— 022	— 180	— 244	— 177	.....
November.....	— 043	— 033	— 114	— 074	+ 075	+ 075	+ 197	+ 196	— 006	— 065	— 099	— 102	.....
December.....	— 059	+ 137	+ 062	— 017	+ 062	+ 112	+ 142	+ 173	— 071	— 254	— 174	— 122	.....
Year.....	— 257	— 091	— 099	— 031	+ 112	+ 187	+ 298	+ 351	+ 167	— 108	— 260	— 265	.....
Summer.....	— 421	— 279	— 184	— 007	+ 137	+ 257	+ 435	+ 460	+ 331	— 016	— 325	— 389	.....
Winter.....	— 094	+ 091	— 014	— 036	+ 088	+ 118	+ 161	+ 241	+ 064	— 200	— 195	— 142	.....

Annual inequality in the diurnal variation of the total force.

The comparison of the above diurnal variations for summer and winter, with that of the whole year, is given in the following table:

TABLE IX.

0.000.

	0h.	2.	4.	6.	8.	10.	Noon.	14.	16.	18.	20.	22h.	m. 21.1.
Summer.....	— 164	— 185	— 085	+ 024	+ 025	+ 070	+ 137	+ 109	+ 164	+ 092	— 065	— 124	.....
Winter.....	+ 163	+ 185	+ 085	— 025	— 024	— 069	— 137	— 110	— 163	— 092	+ 065	+ 123	.....

These tabular quantities are exhibited in diagram E, which closely resembles diagram B, Part VIII, of the vertical force.

The hours of no semi-annual change are 6 a. m. and 7 p. m. The greatest changes take place about 2 a. m. and 4 p. m., with a range of .000370 and .000328 parts of the force, respectively.

The turning epochs are found from the variations at the hours 6 a. m. and 7 p. m. The following numbers are the differences from the respective annual means. For 20h. the sign has been changed.

Month.	6 a. m.	Mean 18 and 20.	Mean 6 a. m., 7 p. m.	Month.	6 a. m.	Mean 18 and 20.	Mean 6 a. m., 7 p. m.
January.....	+ 027	— 122	— 048	July.....	+ 100	+ 097	+ 098
February.....	— 084	— 037	— 060	August.....	— 025	+ 091	+ 033
March.....	— 037	— 095	+ 066	September.....	— 111	+ 055	— 028
April.....	+ 046	+ 060	+ 053	October.....	— 025	— 044	— 034
May.....	+ 104	+ 080	+ 092	November.....	— 043	— 059	— 051
June.....	+ 030	+ 090	+ 060	December.....	+ 014	— 116	— 051

All expressed in units of the sixth place of decimals.

The values in the last column are represented by the formula—

$$A_a = 0.000075 \sin (\theta + 280^\circ) + 0.000025 \sin (2\theta + 131^\circ),$$

θ counting from January 1. The change of sign occurs about April 4 and about September 12. On the average, therefore, the change takes place about three days after the equinoxes.

Analysis of the solar-diurnal variation of the total force.

The solar-diurnal variation of the total force has also been expressed by Bessel's periodic function. θ is counted from midnight, at the rate of 15° an hour; a positive sign indicates increase of total force; a negative sign the reverse. The coefficients are expressed in parts of the force. The formulae are deduced directly from Table VIII.

Diagram F exhibits the observed and computed diurnal variation for the summer months, and diagram G for the winter months. Diagram H exhibits the diurnal variation of the total force for summer, winter, and the whole year.

The diurnal curve is single-crested in summer, and, on the average, during the year; but in winter it assumed a double-crested form, having a secondary maximum between 2 and 3 a. m., and a secondary minimum about 6 a. m. The principal maximum in summer occurs about 2 p. m., and in winter about one and a half hour earlier. The principal minimum in summer occurs about 10 p. m.; in winter about two hours earlier. The summer range is about 0.0009 and the winter range about 0.0004 parts of the force.

The following table contains the computed times of the principal maximum and minimum, together with the elapsed time, amount, and range of variation in force for each month and season; also the time and amount of range of the early morning secondary wave, as taken from the diagrams:

TABLE X.—*Total force.*

1841 to 1845.	Principal maxi- mum.	Amount, 0.000	Principal mini- mum.	Amount, 0.000	Elapsed time.	A. m. and p. m. range, 0.00	A. m. secondary maximum.	A. m. secondary minimum.	Secondary range, .000
	<i>h. m.</i>		<i>h. m.</i>		<i>h. m.</i>		<i>h.</i>	<i>h.</i>	
January.....	13 02	+ 225	19 38	— 283	6 36	0508	3	7½	15
February.....	14 00	+ 320	20 19	— 331	6 19	0651	1	4	07
March.....	13 07	+ 237	20 45	— 204	7 38	0441	4	7	04
April.....	14 46	+ 299	21 54	— 342	7 08	0641	—	—	—
May.....	14 46	+ 422	22 57	— 404	8 11	0826	—	—	—
June.....	13 41	+ 521	22 32	— 486	8 51	1007	—	—	—
July.....	14 04	+ 560	23 05	— 522	9 01	1082	—	—	—
August.....	13 23	+ 618	23 42	— 447	10 19	1065	—	—	—
September.....	13 54	+ 498	23 33	— 360	9 39	0858	—	—	—
October.....	11 00	+ 190	20 30	— 266	9 30	0456	2½	5	04
November.....	12 50	+ 199	20 02	— 118	7 12	0317	0½	4½	04
December.....	12 33	+ 193	19 29	— 231	6 56	0424	3	7	05
Summer.....	14 02	+ 485	22 38	— 421	8 36	0906	—	—	—
Winter.....	12 58	+ 220	20 11	— 229	7 13	0449	2½	6	04
Year.....	13 36	+ 344	21 28	— 296	7 52	0640	—	—	—

The amount and range are expressed in parts of the force. The time of the principal maximum and minimum is computed to the nearest minute or two. The diurnal range is greatest during summer, and least during winter. The small secondary inflexion obtains only during the winter months. Its range is only about the seventieth part of the larger annual range.

Table XI contains the principal morning and afternoon epoch of the normal value of the total force.

The morning epoch is taken from the diagrams; the afternoon epoch is computed.

TABLE XI.—*Epochs of normal total force.*

1841 to 1845.	A. M.	P. M.
	<i>h.</i>	<i>h. m.</i>
January	9	4 02
February	7	5 16
March	8½	4 51
April	5½	6 15
May	5½	6 22
June	6½	6 07
July	5½	6 13
August	7½	6 03
September	8	6 35
October	Not reached.	4 18
November	7½	4 48
December	Not reached.	3 42
Summer	6.5	6 15
Winter	7.4	4 35
Year	6.6	5 38

Annual inequality of the dip and total force.

The differences of the monthly normals, expressed in parts of the horizontal force, have been taken from Table XII of Part V. The mean of the October and December values, however, has been substituted for the November value, which produced a correction of +0.00004 to each monthly value to balance the annual sum. The approximate values of the annual inequality of the vertical force are extracted from Part VIII, after converting the scale divisions into parts of the vertical force.

Table XII contains the values of the annual inequality for the horizontal and vertical components, and, by combination, those of the dip and total force.

TABLE XII.

	$\frac{\Delta X}{X}$	$\frac{\Delta Y}{Y}$	$\Delta \Theta$	$\frac{\Delta \phi}{\phi}$
January	— 0.00045	— 0.00003	+ 0.4	— 0.00008
February	— 15	— 53	— 0.4	— 50
March	+ 23	00	— 0.2	+ 02
April	— 03	— 03	0.0	— 03
May	+ 39	+ 36	0.0	+ 36
June	+ 06	+ 53	+ 0.5	+ 49
July	+ 43	+ 17	— 0.3	+ 19
August	+ 05	+ 20	+ 0.2	+ 19
September	— 20	— 20	0.0	— 20
October	— 13	— 13	0.0	— 13
November	— 12	— 40	+ 0.3	— 37
December	— 11	— 03	+ 0.1	— 04

* From what has been said of the annual inequality of the horizontal and vertical force, it could not be expected that this inequality should appear in any decided manner in the dip and total force. With reference to the dip, all that can be concluded is that the inequality, probably, does not exceed half a minute. At Toronto, where the dip is greater, it is between 0.8 and 0.9; lower in June and July than in January and December; range, 1.7. With respect to the total force, the inequality seems to be about 0.0003 parts of the force, which gives nearly the same range as that found at Toronto, with this difference, however, that at Philadelphia the force is greater in the summer months and less in the winter months, the reverse of what has been found at the other stations.

The next and last part of the discussion of the Girard College magnetic observations will contain the absolute values of the magnetic declination, dip, and intensity.

APPENDIX No. 18.

DISCUSSION OF THE MAGNETIC AND METEOROLOGICAL OBSERVATIONS MADE AT THE GIRARD COLLEGE OBSERVATORY, PHILADELPHIA, IN 1840, 1841, 1842, 1843, 1844, AND 1845. PART XII.—DISCUSSION OF THE MAGNETIC INCLINATION, AND TABLE OF ABSOLUTE VALUES OF THE DECLINATION, INCLINATION, AND INTENSITY, BETWEEN 1841 AND 1845. BY A. D. BACHE, LL.D., PRESIDENT NATIONAL ACADEMY SCIENCES, SUPERINTENDENT UNITED STATES COAST SURVEY.

[From the Smithsonian Contributions to Knowledge.]

Results and discussion of the observations for magnetic inclination taken at Girard College, Philadelphia, in 1842, 1843, and 1844.

The dip circle was made by Robinson, of London, in 1836, and is six inches in diameter.* The needles used are No. 1 and No. 2, and the poles were reversed in each set of observations. The ends of the needles are marked A and B. The instrument was mounted upon a marble pier about 20 feet to the southeast of the observatory. The observations for dip were made once each week, and were commenced in January, 1842; they terminated in July, 1844. There are some interruptions, however, in the series of observations, as will be noticed in looking over the results of Table No. 1. This table contains an abstract of the results taken directly from the record. It has also been compared with the synopsis of the resulting dips in volume III of the record. The time is observatory mean time, counted, for convenience, from 0h. to 24h. Each mean result consists of twenty-four separate measures, with face of instrument west and east, marked side of the needle west and east, and with polarity north and south. Three readings have been taken in each position of face of the needle. With but a few exceptions, needle No. 1 was employed throughout the series. In the exceptional cases, where needle No. 2 or one of the Lloyd needles No. 1 or No. 3 were used, special corrections to refer their indications to the result by needle No. 1 have been deduced and applied.

* It is the same instrument with which I made the observations at stations in Europe, (Amer. Phil. Trans., vol. VII, part 1, 1840,) and those in the magnetic survey of Pennsylvania in 1840 and 1841, and at other stations further northward and eastward in 1843.

TABLE NO. 1.—Abstract of results of magnetic dip observed at Girard College Observatory between 1842 and 1844.

Year and month.	Day.	Hour.	Minute.	Dip, needle No. 1.			Mean monthly dip.	Year and month.	Day.	Hour.	Minute.	Dip, needle No. 1.			Mean monthly dip.	
				A north.	B north.	Mean.						A north.	B north.	Mean.		
1842.				° ' "	° ' "	° ' "	° ' "	1843.				° ' "	° ' "	° ' "	° ' "	
January.....	4	10	0	71 56.4	71 55.2	71 55.8	71 57.5	July.....	4	10	25	72 01.4	71 56.3	71 58.8	71 57.5	
	11	10	0	71 58.6	71 53.6	56.1			11	10	35	72 07.9	71 44.3	56.1		
	18	10	0	72 00.9	71 55.0	57.9			18	10	5	72 04.9	71 51.5	58.2		
	25	10	0	71 56.3	72 04.4	60.3			18	11	20	71 58.8	71 55.5	* 57.2		
February.....	1	10	0	72 01.9	71 57.1	59.5	71 58.4							+1.7	71 60.5	
	8	10	0	72 03.6	71 55.1	59.4			20	16	37	71 56.2	71 45.3	56.7		
	15	10	0	71 58.0	71 53.2	55.6						+1.9	+10.0			
	22	10	0	72 02.0	71 56.7	59.3		August.....	22	10	5	71 53.4	72 12.3	64.1		
March.....	1	10	0	72 08.1	71 49.5	58.8	71 59.5							-1.8	71 60.7	
	8	10	0	72 04.6	71 51.0	57.8			24	11	17	72 02.0	71 50.7	56.3		
	15	10	0	72 07.5	71 52.7	60.1			24	12	0	72 01.6	72 00.2	* 60.9		
	22	10	0	72 08.2	71 55.7	62.0								+1.7		
April.....	29	10	0	72 02.6	71 54.9	58.7	71 59.0		26	17	46	71 54.0	71 51.2	58.6	71 60.5	
	5	10	0	71 46.4	71 55.5	51.0						+1.9	+10.0			
	12	10	30	72 06.2	71 57.0	61.6			29	10	25	72 05.1	71 55.5	60.3		
	19	9	35	72 08.5	71 55.3	61.9			29	11	55	71 56.3	71 50.3	59.3		
May.....	26	9	58	72 10.5	71 52.4	61.4	71 61.3							+1.9	71 60.7	
	3	10	19	72 11.4	71 56.1	63.7		September.....	5	9	42	72 07.3	71 52.0	59.6		
	17	9	29	72 09.4	71 59.4	{ 64.4			5	11	12	71 58.9	71 49.3	60.0		
	17	10	43	71 54.2	72 02.6	{ 58.4						+1.9	+10.0			
	24	10	0	72 11.6	71 51.3	61.4	71 60.7		12	9	56	72 02.7	71 53.7	58.2	71 60.7	
June.....	31	10	1	72 06.7	71 48.9	57.8			12	11	17	71 54.8	71 57.0	{ 55.9		
	7	10	15	72 11.8	71 53.4	62.6								+1.7		
	14	9	46	72 09.1	71 52.9	61.0			12	13	5	71 57.1	71 48.4	58.7		
July.....	21	9	56	71 57.1	71 59.1	58.1	71 60.7							+1.9	71 54.8	
	28	9	24	72 07.8	71 54.3	61.0			19	9	40	72 02.9	71 59.6	61.3		
	13	9	11	72 10.2	71 58.3	64.3			26	9	52	72 04.1	72 03.1	63.6		
	19	9	52	71 54.2	71 53.1	53.6		October.....	3	9	25	71 55.2	71 49.0	52.1		
August.....	26	9	34	71 49.2	71 57.9	53.6	71 57.2		10	9	32	71 56.9	71 55.2	56.0	71 54.8	
	3	9	42	73 01.4	72 00.5	61.0			17	9	42	71 50.8	72 00.7	55.7		
	9	10	1	72 06.3	71 53.5	59.9			24	9	40	72 00.1	71 53.4	56.8		
	16	9	57	72 04.2	71 54.8	59.5		November.....	31	9	32	71 56.3	71 51.0	53.6		
September.....	30	9	40	72 05.0	71 56.2	60.6	71 60.2		7	9	45	72 01.2	71 51.5	56.4	71 56.4	
	6	9	4	72 10.0	71 58.7	64.3			14	10	17	72 00.7	71 57.5	59.1		
	13	9	55	71 56.7	71 58.8	57.8			21	10	10	72 02.1	71 47.7	54.9		
	27	9	43	72 08.6	71 54.6	61.6			28	10	25	72 02.5	71 48.1	55.3		
October.....	4	10	12	72 07.0	71 55.4	61.2	71 61.2	December.....	5	10	20	72 01.9	71 51.7	56.8	71 57.7	
	11	10	8	72 06.4	71 55.6	61.0			12	10	42	72 05.7	71 58.3	62.0		
	11	11	17	71 51.3	72 03.2	* 57.2			19	10	12	71 59.0	71 51.8	55.4		
						+1.7			26	10	40	72 00.5	71 52.6	56.6		
November.....	1	10	6	72 11.9	72 01.5	66.7	71 60.6	1844.								71 59.5
	15	9	48	72 08.3	71 52.3	60.3		January.....	2	10	20	71 57.6	71 53.8	55.7		
	22	10	13	72 13.3	71 57.1	65.2			9	9	52	72 04.0	71 54.0	59.0		
	27	9	16	72 08.2	71 55.3	61.7			16	10	40	72 01.2	71 52.8	57.0		
December.....							71 61.7		23	10	12	71 57.8	71 50.5	54.1	71 58.2	
									30	10	17	71 58.9	71 51.7	55.3		
1843.								February.....	6	10	25	71 59.3	71 57.9	58.6		
April.....	11	10	53	71 58.0	71 42.5	50.3	71 54.9		13	10	22	72 01.0	71 59.1	60.0		
	18	13	10	72 08.2	71 48.9	58.5			20	10	12	71 59.1	72 01.2	60.1		
	25	10	0	71 59.7	71 52.0	55.8			27	10	47	71 59.7	71 58.5	59.1		
May.....	2	9	40	72 11.7	71 44.7	58.2		71 63.2	March.....	5	11	10	71 56.6	71 59.1	57.8	
	9	9	25	72 11.8	72 08.2	70.0			12	9	56	71 56.6	71 58.7	57.7		
	16	10	22	72 09.3	72 14.9	67.6			19	10	22	72 01.5	72 02.2	61.9		
	23	9	50	71 59.2	72 12.9	66.1			26	9	55	71 58.6	71 55.3	57.0		
June.....	30	9	55	72 05.6	71 42.7	54.1	71 57.7	April.....	2	10	57	72 04.1	71 52.7	58.4		
	6	10	22	72 09.5	71 54.5	62.0			9	10	1	71 55.2	71 54.8	55.0		
	13	10	20	72 10.7	71 57.8	64.2			16	10	7	71 59.1	71 55.9	57.5		
	20	10	5	71 56.5	71 45.4	51.0			23	10	18	71 55.7	71 49.4	52.6		
	27	9	55	71 58.8	71 48.2	53.5		30	9	55	72 00.6	71 51.5	56.1			

* Needle No. 2.

† Lloyd needle No. 3, A end north.

‡ Needle No. 2, B end north.

† Lloyd needle No. 1, A end north.

§ Needle No. 1, B end north.

TABLE NO. 1.—*Abstract of results of magnetic dip, &c.*—Continued.

Year and month.	Day.	Hour.	Minute.	Dip, needle No. 1.			Mean monthly dip.	Year and month.	Day.	Hour.	Minute.	Dip, needle No. 1.			Mean monthly dip.
				A north.	B north.	Mean.						A north.	B north.	Mean.	
1844.				° ' "	° ' "	° ' "	° ' "	1844.				° ' "	° ' "	° ' "	° ' "
May	7	9	50	71 57.2	71 54.5	71 55.8	71 57.1	July	4	12	53	71 56.5	71 56.6	71 56.6	71 58.9
	14	9	49	71 59.0	71 54.4	56.7			16	10	37	72 02.1	72 06.7	64.4	
	21	10	2	71 57.5	71 57.0	57.3			23	10	48	71 56.3	71 57.7	57.0	
	28	9	50	71 59.5	71 57.6	58.5			30	10	40	72 00.4	71 54.8	57.6	
June	18	11	47	71 59.5	71 55.1	57.3	71 57.3								

Determination of corrections to results by needle No. 2, by Lloyd needles Nos. 1 and 3, and for want of reversal of polarity for needles Nos. 1 and 2, on August 22, 1843.—Needle No. 1 being that ordinarily used, the exceptional readings with the other three needles have been referred to the indications of needle No. 1.

The index error to needle No. 2 we find by direct comparison with needle No. 1 on the following dates:

May	17, 1842.	Correction, +6.0	} Mean, +1.7.
October	11, 1842.	Correction, +3.8	
July	18, 1843.	Correction, +1.0	
August	24, 1843.	Correction, -4.6	
September	12, 1843.	Correction, +2.3	

The correction to the Lloyd needles Nos. 1 and 3, A end north, we obtain also by direct comparison, viz:

August	29, 1843.	Correction to Lloyd No. 1, +4.0; to Lloyd No. 3, +10.0
September	5, 1843.	Correction to Lloyd No. 1, +0.7; to Lloyd No. 3, +10.3
September	12, 1843.	Correction to Lloyd No. 1, +1.1; to Lloyd No. 3, +9.8
Mean correction, +1.9		+10.0

The corrections for polarity to needles 1 and 2 are determined as follows:

For needle No. 1.—Mean dip in 1843 from 34 results, A north.....	71 62.4
Mean dip in 1843 from 34 results, B north.....	71 53.8
Mean dip.....	71 58.1

Hence, correction to needle 1, A north, -4.3, and B north, +4.3.

For needle No. 2 we have the following differences:

May	17, 1842.	A north—B north, -8.4	} Mean, -3.6.
October	11, 1842.	A north—B north, -11.9	
July	18, 1843.	A north—B north, +3.3	
August	24, 1843.	A north—B north, +1.4	
September	12, 1843.	A north—B north, -2.2	

Hence, correction to needle 2, A north, +1.8; B north, -1.8.

The above corrections have been applied.

REPORT OF THE SUPERINTENDENT OF

Recapitulation of monthly means of inclination.

Month.	1842.	1843.	1844.
	71° +	71° +	71° +
January	57.5	.....	56.2
February	58.4	.....	59.5
March	59.5	.....	58.6
April	59.0	54.9	55.9
May	61.3	63.2	57.1
June	60.7	57.7	57.3
July	57.2	57.5	58.9
August	60.2	60.5	.....
September	61.2	60.7	.....
October	60.6	54.8	.....
November	64.1	56.4	.....
December	61.7	57.7	.....
Mean	60.1	58.2	57.6

The preceding results indicate an annual diminution of the dip of 1'. To complete the dip for the year 1843, the values for January, February, and March have been interpolated, by taking the means of 1842 and 1843 of these months, respectively. The interpolated dips are 71° 56.9, 58.9, and 59.0. We have the final values:

Dip for 1842.5	72° 01.1
Dip for 1843.5	71° 58.2
Dip for 1844.4	71° 57.6

If we divide the monthly means (inclusive of the interpolated dips for January, February, and March, 1843) into two parts, we find the values—

From January, 1842, to April, 1843, inclusive	71° 59.4
From April, 1843, to July, 1844, inclusive	71° 57.9

The corresponding epochs are September 1, 1842, and December 1, 1843, which again gives an annual decrease of 1'. It is desirable, however, to extend the investigation of the annual effect of the secular change of the dip beyond the years above stated. In the Coast Survey report for 1856,* Assistant Schott discussed the secular change of the dip at various places, and finds that the middle of the year 1842 (1842.7 ± 0.7 years) was an epoch of minimum dip for places between Cambridge, Massachusetts, Toronto, Canada, and Washington, District of Columbia. The expression for the secular change for Philadelphia (page 241 of the 1856 report) is derived from 19 observations, contracted to 8 normals, between 1834 and 1855.

The dips extracted from a manuscript paper on my magnetic surveys in various parts of the northeastern States during the years 1834-'35, 1840, 1841, and 1843 are as follows:

Observed dip at Philadelphia:

July 21, 1840	71° 52.6
October 28, 1840	71° 53.0
April 26, 1841	72° 00.6
July 20, 1841	71° 57.0
October 9, 1841	71° 58.2
November 1, 1841	71° 59.1

* Appendix No. 32, page 235.—Discussion of the secular variation of the magnetic inclination in the Northeastern States.

A collection and combination of all the observed values for dip at Philadelphia (as far as they have come to my notice) are given in the following table :

Date.	Observer.	Dip.	Mean dip.	Mean epoch.
July, 1834	Professor Bache and Professor Courtenay	$\begin{smallmatrix} 71 & 60.2 \\ 71 & 60.2 \end{smallmatrix}$	$\begin{smallmatrix} 72 & 00.2 \\ 72 & 00.2 \end{smallmatrix}$	1834.5
July, 1838	Professor Bache	71 43.9	Excluded.	
September, 1839	Professor Loomis	71 67.1	72 07.1	1839.7
July, 1840	Professor Bache	71 52.6	71 53.0	1840.7
September, 1840	do	71 53.3		
October, 1840	do	71 53.0		
March, 1841	do	71 60.7	71 58.4	1841.5
April, 1841	Professor Bache	71 58.2		
Do	do	71 60.6		
Do	do	71 59.0	71 59.7	1842.5
June, 1841	Major Graham	71 54.5		
July, 1841	Professor Bache	71 57.0		
October, 1841	do	71 58.2	71 58.2	1843.6
November, 1841	do	71 59.1		
November, 1842	Doctor Locke	71 60.1		
Do	Captain Lefroy	71 59.0	72 02.0	1844.3
January to December, 1842	Professor Bache	71 60.1		
April to December, 1843	do	71 58.2		
April to December, 1844	Major Graham	71 61.8	72 01.0	1846.4
April, 1844	Doctor Locke	71 59.3		
May, 1844	do	71 69.2		
January to July, 1844	Professor Bache	71 57.6	72 17.7	1855.7
May, 1846	Doctor Locke	71 61.0		
September, 1855	Assistant Schott	71 77.7		
August, 1862	do	71 65.8	72 05.8	1862.6

The annual irregularity in the dip need not be considered, as the index error of the various needles and the observing errors are much greater than the maximum amount of that irregularity, which, according to the Toronto observations, hardly exceeds $\pm 1'$.

Collecting the mean dips and mean epoch, and adopting the expression—

$$\theta = \theta_1 + x + y(t - t_0) + z(t - t_0)^2,$$

where,

θ = resulting dip at any time between 1830 and 1860;

θ_1 = assumed dip at epoch, x its correction, $\theta_1 = 72^\circ 00'$;

t_0 = epoch or 1840.0;

t = any other time between the above limits;

we obtain from the following combination of the observations, by the method of least squares, the values x , y , and z :

		Mean dip.	Mean year.
Group I.	3 results ...	72.00	1838.3
Group II.	5 results ...	72.00	1843.5
Group III.	2 results ...	72.20	1859.2

whence $\theta = +72.00 - 0.00011(t - 1840) + 0.00060(t - 1840)^2$.

The observed and computed dips compare as follows :

Epoch.	Observed dip.	Computed dip.	Obs'd—Com'd.
1834. 5.....	72.00	72.02	— 0.02
1839. 7.....	72.12	72.00	+ 0.12
1840. 7.....	71.88	72.00	— 0.12
1841. 5.....	71.97	72.00	— 0.03
1842. 5.....	72.00	72.00	0.00
1843. 6.....	71.97	72.01	— 0.04
1844. 3.....	72.03	72.01	+ 0.02
1846. 4.....	72.02	72.03	— 0.01
1855. 7.....	72.29	72.15	+ 0.14
1862. 6.....	72.10	72.31	— 0.21

The probable error of any one representation is $\pm 4'.8$. The minimum dip, according to the above formula, occurred in January, 1840; at Toronto this minimum occurred in 1843.

By means of the formula we find the dip for the middle of each year :

Year.	Computed dip.	Observed dip.	Adopted dip.
1840-5.....	72.00	.....	72.59
1841-5.....	72.00	.....	71.59
1842-5.....	72.00	72.00	72.00
1843-5.....	72.01	71.97	71.58
1844-5.....	72.01	71.97	71.58
1845-5.....	72.02	.....	72.01

We may now collect in one table the numerical values of the magnetic elements, as found in the preceding discussion. The units for the force are feet and grains; + indicates west declination and north dip.

Girard College, Philadelphia.

Epoch.	ψ	θ	X	Y	ϕ
January, 1841	+ 3° 23'	+ 71° 59'	4.178	12.85	13.51
1842	3 28	71 59	4.175	12.84	13.50
1843	3 32	71 59	4.173	12.83	13.49
1844	3 36	71 58	4.170	12.81	13.47
1845	3 41	72 00	4.168	12.83	13.49
Mean January, 1843.....	+ 3 32	+ 71 59	4.173	12.83	13.49

The latitude of the observatory is 39° 58.4'
 And its longitude west of Greenwich..... 75° 10.1'
 Or..... 5^h 00^m 40^s.3

To facilitate the use of the several parts of the discussion of the Girard College magnetic observations a complete index is here given.

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APPENDIX No. 19.

RESULTS OF MAGNETIC OBSERVATIONS MADE IN THE UNITED STATES BY PROFESSOR J. N. NICOLLET BETWEEN 1832 AND 1836.—COMMUNICATED BY A. D. BACHE, LL.D., PRESIDENT NATIONAL ACADEMY OF SCIENCES, SUPERINTENDENT UNITED STATES COAST SURVEY.—MAY, 1864.

An examination of an unpublished manuscript of certain magnetic observations, made principally in the interior of the United States by the late Professor J. N. Nicollet, about the epoch 1834, led me to the conclusion that a discussion and publication of the results of these observations might prove advantageous to science. The manuscript is incomplete, as it contains but a small portion of the record, but a summary of most of the crude results, as immediately resulting from the observations, is preserved in Mr. Nicollet's handwriting. Owing to the incompleteness of the record and the imperfection of the instrumental means at that period, the results can claim but a small amount of accuracy. Still, it was thought that their comparatively early date, and the absence of any other and better observations at some of the stations even at the present day, would, nevertheless, attach to them some value, especially in investigations of the secular change of the magnetic elements.

Table of geographical positions of magnetic stations.

Station.	Latitude.	Longitude.	Authority.	Point of reference.
Baltimore, Md.....	39 17.8	76 36.6	United States Coast Survey	Washington monument.
St. Louis, Mo.....	38 37.5	90 15.3	American Almanac, 1861	Chauteau's garden.
Lexington, Ky.....	38 06	84 18	do.....do	
Smithland, Ky.....	37 08	88 30	Colton's Atlas	
Nashville, Tenn.....	36 09.5	86 49.1	American Almanac, 1861	
Knoxville, Tenn.....	35 59	83 54	do.....do	
Warm Spring, N. C.....	35 50	82 48	Colton's Atlas	
Ashville, N. C.....	35 36	82 30	do.....do	
Athens, Ga.....	33 57	83 25	do.....do	
Augusta, Ga.....	33 28	81 54	American Almanac, 1861	
Charleston, S. C.....	32 46.7	79 55.7	United States Coast Survey	Circ. church.
Natchitoches, La.....	31 44	93 05	Colton's Atlas	
Natchez, Miss.....	31 33.8	91 24.7	American Almanac, 1861	Fort; Chotard's residence.
Mobile, Ala.....	30 41.4	88 01.5	United States Coast Survey	Episcopal church; Batre's garden.
New Orleans, La.....	29 57.8	90 02.5	do.....do	Mint.
Tallahassee, Fla.....	30 28	84 36	American Almanac, 1861	
Tuscaloosa, Ala.....	33 12	87 42	do.....do	
St. Peter, Minn.....	44 48	93 10	American Almanac, 1861, and C. A.	Fort Snelling; Major Tagliaferro's.
Cape Henry, Va.....	36 55.5	76 00.2	United States Coast Survey	Light-house.

1.—Horizontal force.

The following table contains the times of 300 vibrations, with five needles, for relative horizontal intensity. At four stations only we have a record of the temperature, which, however, proved insufficient to deduce any corrections for changes of temperature. The observations at each of the four stations are very consistent among themselves. The results by a sixth needle (No. 12) were rejected by Mr. Nicollet, the irregular results justifying their rejection.

General table of times of 300 vibrations of 5 needles for horizontal intensity.

Locality.	Date.	Needles.					Mean.
		No. 1.	No. 2.	No. 11.	No. 13.	No. 14.	
Baltimore	July, 1832	<i>s.</i> 1102	<i>s.</i> 1132	<i>s.</i> 1149	<i>s.</i> 1059	<i>s.</i> 966	<i>s.</i> 1081.6
St. Louis	July, 1835	1081	1132	1098	1117	1040	1093.6
Nashville	November, 1833	1016	1061	[1072]	1200	1009	1071.5
Athens	May, 1833	975	1020	952	957	911	963.0
Do	August, 1834	991	1038	994	1007	944	994.8
Do	September, 1834	989	1029	974	994	913	979.8
Augusta	February, 1833	973	1015	950	954	907	959.8
Charleston	January, 1833	965	989	939	947	856	939.2
Natchez	May, 1834	929	970	922	938	884	928.6
Mobile	do	935	979	930	935	877	931.2
Do	May, 1835	947	993	957	976	912	957.0
Natchez	March, 1836	954	1001	972	990	920	967.4
St. Louis	June, 1836	1076	1127	1093	1112	[1027]	1086.9
St. Peter	July, 1836	1239	1295	1263	1286	1190	1254.6

The two values in brackets were interpolated as follows: For needle No. 11 the mean of the four needles Nos. 1, 2, 13, and 14 was taken, and the result by No. 11 compared with it for each station. The mean difference was thus obtained, and applied to the mean of the other needles at Nashville. For needle No. 14 the mean of Nos. 1, 2, 11, and 13 was compared with No. 14, and the correction for St. Louis applied accordingly.

The next table contains the time T of one vibration and the values of $\frac{1}{T^2}$, which are proportional to X , the horizontal force. By means of this column we obtain an approximate value for the loss of magnetism of the needles, which appears to have been considerable. Taking the differences for the two epochs at St. Louis, Athens, Mobile, and Natchez, we find a loss for 61 months of 0.016154, and for one month of 0.000265. The next columns contain the difference, in months, from the adopted epoch, July, 1834, the correction for loss of magnetism, and the corrected values $\frac{1}{T^2}$.

Station.	Date.	T .	$\frac{1}{T^2}$	Differential epoch.	Correction for loss of magnetism.	Corrected $\frac{1}{T^2}$	Mean.
Baltimore	July, 1832	<i>s.</i> 3.605	<i>m.</i> 0.076945	+ 24	- 6360	0.070585	.....
St. Louis	July, 1835	3.645	0.075266	- 12	+ 3180	0.078446	.....
Nashville	November, 1833	3.572	0.078375	+ 8	- 2120	0.076255	.....
Athens	May, 1833	3.210	0.097051	+ 14	- 3710	0.093341	.....
Do	August, 1834	3.316	0.090945	- 1	+ 265	0.091210	.....
Do	September, 1834	3.260	0.093746	- 2	+ 530	0.094278	0.092943
Augusta	February, 1833	3.199	0.097719	+ 11	- 2915	0.094804	.....
Charleston	January, 1833	3.131	0.102009	+ 13	- 3180	0.098829	.....
Natchez	May, 1834	3.095	0.104395	+ 2	- 530	0.103865	.....
Mobile	do	3.104	0.103791	+ 2	- 530	0.103261	.....
Do	May, 1835	3.190	0.098270	- 16	+ 2650	0.100920	0.102090
Natchez	March, 1836	3.225	0.096148	- 20	+ 5300	0.101448	0.102657
St. Louis	June, 1836	3.623	0.076183	- 23	+ 6095	0.082278	0.080362
St. Peter	July, 1836	4.182	0.057179	- 24	+ 6360	0.063539	.....

To introduce the horizontal force in absolute value we have X for Baltimore, St. Louis, and Mobile, as follows:

Baltimore, (Coast Survey report for 1861, Appendix No. 22, page 247:) The mean of the first three values or $X=4.255$; the value of X changes but little in seven years.

St. Louis, (reference as above:) The first value or $X=4.705$ is adopted; X changes but little in four years.

Mobile, (Coast Survey report for 1858, page 192 :) X in 1857 = 6.143; hence, in 1834, 6.214, assuming an annual diminution of 0.0005 parts of the force.

Introducing these values, we can form three columns of results, the mean of which has been adopted as an approximation to the horizontal force, expressed in grains and feet.

				X.
Baltimore	4.255	4.133	4.296	4.228
St. Louis	4.844	4.705	4.892	4.814
Nashville	4.597	4.465	4.642	4.568
Athens	5.603	5.442	5.657	4.568
Augusta	5.715	5.551	5.771	5.679
Charleston	5.958	5.786	6.015	5.920
Natchez	6.188	6.010	6.249	6.149
Mobile	6.154	5.977	6.214	6.115
St. Peter	3.830	3.720	3.868	3.806

2.—Inclination.

The records of the observations are preserved for two stations only, viz : St. Louis and St. Peter. At St. Louis the method by vibrations in the meridian, and at right angles to it, was employed. This method originated with Laplace, was tested by General Sabine in 1821, also by Rumker and Quetelet; but it appears to have been abandoned since, owing to the imperfection of the results when compared with those obtained by means of a dip circle. It should be remarked that the method applies more properly to small dips. Let m = the time of a vibration of a horizontal needle in the meridian; p = the time of a vibration when perpendicular to the magnetic meridian; then $\sin I = \frac{m^2}{p^2}$; Mr. Nicollet expressing his inclination as measured from the vertical. He also used an inclinorium, four position results being given for each resulting inclination. At St. Louis, by the first method, the inclination was $18^\circ 41'$; by the second method, $19^\circ 04'$. At St. Peter the second method alone was used. As to the method used at the stations given in the general table of results there is no information. The dip, however, as given, is largely affected with index error. I have endeavored to determine an approximate value, at least, of this error, as, without this correction, the results would be of no value.

For St. Louis the following observations are on record :

Year.	Observer.	Reference.	Observed.	Computed.	O—C.
1819.4.....	Long	Account of Major Long's expedition.	$70^\circ 30'$	$70^\circ 36'$	— 6
1839.5.....	Locke	Am. Phil. Soc., 1846	69 31.4	69 24	+ 7
1841.7.....	Nicollet	Am. Phil. Soc., 1843	69 27.1	69 16	+ 11
1841.7.....	Loomis	Am. Phil. Soc., 1843	69 25.5	69 16	+ 9
1856.8.....	Friesach	Vienna Academy, 1858	68 01	68 22	— 21

which observations can be expressed by $I = 69^\circ 23' - 3.6(t - 1839.8)$.

Three results by Nicollet for the mean epoch, 1836.0, give $71^\circ 00'$; by the formula we find $69^\circ 37'$; hence correction, $-1^\circ 23'$. At Natchitoches Major Graham observed, in 1840, (Sill. Jour. IV, 1847,) $61^\circ 15.9$; and assuming an annual rate of change of $-2'$, the result referred to the date of Nicollet's observation, 1834.3, would be $61^\circ 27'$; by Nicollet, $64^\circ 01'$; hence correction, $-2^\circ 34'$.

At Mobile Mr. Goodfellow, of the United States Coast Survey, found $60^\circ 51'$ in 1857, which, when referred to 1834.5, would probably be $61^\circ 36'$; Nicollet has $63^\circ 28'$; hence correction, $-1^\circ 52'$. At New Orleans Mr. Dean, of the United States Coast Survey, found $59^\circ 46.5$ in 1858, which, when referred to 1834.3, would probably be $60^\circ 34'$; Nicollet has $62^\circ 05'$; hence correction, $-1^\circ 31'$.

The mean of these four corrections, or $-1^\circ 50'$, has provisionally been applied to the observed dips.

Possibly hereafter, when the secular change of the dip is better understood, a more perfect correction can be made out. The tabular results are only rough approximation. The manuscript record, nevertheless, indicates that the observations were made with great care, subject only to a large index error.

The quadrant of Nicollet's inclinorium was divided into 90° , as stated by him.

Place.	Date.		Observed dip.	Approx. cor- rected dip.	
St. Louis	July, 1835	19 02	70 58	69 10	Mean for 1836.0.
Smithland	Dec., 1833	19 59	70 01	68 11	
Nashville	Nov., 1833	21 05	68 55	67 05	
Knoxville	Sept., 1833	21 04	68 56	67 06	
Warm Spring	Sept., 1833	20 31	69 29	67 39	
Ashville	Sept., 1833	20 45	69 15	67 25	Mean for 1834.3.
Athens	May, 1833	22 17	67 43	65 40	
Athens	Aug., 1834	22 25	67 35	-----	
Athens	Sept., 1834	22 47	67 13	-----	
Natchitoches	April, 1834	25 59	64 01	62 11	
Natchez	Mar., 1834	25 59	64 01	62 11	Mean for 1834.9.
Mobile	May, 1834	26 21	63 39	61 38	
New Orleans	April, 1834	27 55	62 05	60 15	
Tallahassee	Jan., 1835	26 47	63 13	61 23	
Tuscaloosa	April, 1835	23 48	66 12	64 22	
Mobile	May, 1835	26 44	63 16	-----	
St. Louis	June, 1836	19 09	70 51	-----	
St. Louis	Aug., 1835	18 49	71 11	-----	
St. Peter	July, 1836	14 10	75 50	74 00	

3.—Declination.

The papers contain the declination at one station—Cape Henry, Virginia. The record is very complete, and the results seem to be entitled to full confidence. The locality is an important one geographically, as well as magnetically, for the study of the secular change of the declination the result is of much value.

The following are the individual results:

1832, June 9.—0 52.5 W.	} Mean, $0^\circ 45'$ W.
June 10.—0 47.6 W.	
June 10.—0 41.3 W.	
June 11.—0 42.3 W.	
June 11.—0 41.0 W.	

These observations were obtained by means of a Shenck boussole.

For the discussion of the secular change we have at this station the following values:

Year.	Observer.	Reference.	Declination.
1732	Hoxton	Hansteen's Erdmagnetismus	0 42 W.
1732 .....	.....	Douglass' History	4 40 W.
1775 .....	.....	Des Barres's Atlantic Neptune	5 00 W.
1823.5	H. Boyé	State map of Virginia, 1859	1 32 W.
1832.5	J. A. Nicollet	Manuscript	0 45 W.
1856.7	C. A. Schott	United States Coast Survey Report, 1858	1 28 W.

The position of the light-house at Cape Henry is in latitude $36^\circ 55.5'$, longitude $76^\circ 00.2'$ west of Greenwich.

APPENDIX No. 20.

REPORT OF ASSISTANT GEORGE W. DEAN ON EXPERIMENTS MADE FOR DETERMINING THE "EDUCATION TIME" OF RELAY MAGNETS OR TELEGRAPHIC "REPEATERS." (SKETCH No. 39.)

NEW YORK, June 15, 1864.

DEAR SIR: Your instructions, dated November 24, 1862, authorized me to obtain information in regard to the location and working condition of the telegraph lines between Washington city and San Francisco, California, and more particularly the overland Pacific lines; the view being to ascertain the best plan for exchanging time and star signals by telegraph for the establishment of the difference of longitude between those two places. I was further authorized to obtain the requisite instruments and telegraph apparatus, and proceed to the Coast Survey Office at Washington, and there make such experiments with "relay magnets," generally known as "telegraph repeaters," as might be deemed expedient for the successful execution of the proposed telegraphic longitude operations.

In executing that portion of your instructions relating to the location and working condition of the several lines, I obtained much valuable information by correspondence with J. H. Wade, esq., president of the Pacific Telegraph Company; Colonel Anson Stager, general superintendent United States military telegraph lines; General Marshall Lefferts, engineer for the American Telegraph Company, and several other gentlemen, who possess much practical knowledge relating to telegraph matters. These inquiries were further extended by personal inspection of some of the principal telegraph stations at the west, and for this purpose I visited the cities of Cleveland, Cincinnati, St. Louis, and Chicago during the month of May, 1863.

Those facts thus collected which have a direct bearing upon the execution of the proposed longitude operations were presented in a brief report submitted to you in September last. I now have the honor to report the results of my experiments for determining the "*education time*" of electro-magnets of various forms of construction. It may be proper to explain more definitely the sense in which I here use the expression "*education time*."

In every chronographic record which may be made through an electro-magnet, a certain interval of time, however small, must elapse between the instant that a signal is made and that of its record upon the fillet or chronographic paper. The Coast Survey telegraphic experiments for differences of longitude have been chiefly made through electro-magnets in a *closed circuit*; consequently the signals have been made by *breaking* the galvanic circuit, at which instant the induced magnetism of the electro-magnet becomes suddenly diminished, until its attractive power is overcome by the tension of the armature spring, thereby transmitting the signal to the chronographic paper. In case the *open circuit* is used, which in a few instances has been adopted, of course the operation becomes reversed; in other words, the "*induction time*" would be the interval between the *closing* of the circuit and the instant that the induced magnetism of the coils became sufficiently strong to overcome the tension of the armature spring.

In conducting telegraphic experiments, overland, for ascertaining differences of longitude, the *closed* circuit appears to have several advantages over the *open* circuit. All the experiments which I am about to describe have been made in the *closed* circuit.

In completing the arrangements for making these interesting and delicate experiments, the idea occurred to me that either the *induction* or *education time* could be measured more accurately by means of the chronographic method, with *two break circuits* in the astronomical clock, than by any other. This apparatus was accordingly constructed under my direction by one of the mechanics at the Coast Survey Office, Mr. Hunt.

A detailed description of the single-break circuit is given in your report for the year 1856, Appendix No. 21. It consists essentially of a delicate platinum tilt-hammer pivoted on one insulated brass plate, while its head rests upon another, the two plates being connected with the opposite poles of the battery. When the pendulum at each oscillation reaches the vertical, a projecting pin in its centre trips the hammer, thus breaking the circuit and causing a record.

To make the double-break, an additional tilt-hammer was added, constructed in an analogous manner, but so adjusted that it was touched by the pin and tripped at the *highest* point of the oscillation of the pendulum.

Sketch No. 39 sufficiently explains these various parts: C is the insulating bar of ivory; f^1 the brass plate upon which is pivoted the tilt-hammer, a ; f the brass plate upon which the head of the tilt rests; A, A^1 , are binding posts connecting the brass plates in the circuit.

The second break-circuit is attached to the lower part of the insulating bar, C; g^1 is the brass plate to which the second tilt-hammer, $b\ b^1$, is pivoted, and g is the one upon which its head, \bar{b} , rests; B and B^1 are the binding posts connecting these plates in the second circuit; h is a screw for adjusting the position of the tilt, $b\ b^1$.

The clock was adjusted to sidereal time, and its daily rate did not exceed a second.

The method pursued in determining the *eduction time* of electro-magnets was as follows:

The difference of time between the two clock-breaks at every alternate second was first ascertained by connecting the two break-circuits, a and b , in the same galvanic circuit, in which also were connected a chronograph and a first-class fillet register.

The signals thus made by the clock, one being at the *centre* of each oscillation, the other at the highest point of every alternate oscillation, were recorded by the chronograph and fillet registers. The record of these clock-signals was continued about one minute, which gave thirty comparisons of the difference of time between the two signals. This difference was found to be between forty-seven and forty-eight hundredths of a second. It is proper here to remark that in recording the clock signals a second of time was represented upon the fillet paper by a line about two inches in length, while upon the chronograph paper it was indicated by a space a little less than half an inch long; hence the greater accuracy in measuring the fractional parts of the second upon the fillet paper induced me to rely chiefly upon that record.

The comparison of the two clock-breaks having been made, a relay-magnet (Sketch No. 66) was connected in the clock-circuit, B, B^1 , while the break-circuit apparatus, A, A^1 , remained in the direct circuit with the chronograph register. It will be observed that all the clock signals made through the tilt-hammer a are immediately recorded by the chronograph, while those made by the tilt-hammer b are transmitted through the relay-magnet before they can be recorded by the chronograph. A comparison of the signals thus recorded with those previously made when both clock signals were transmitted through the *same circuit* enables us to obtain the *eduction time* of the relay magnet in the clock-circuit, B, B^1 .

In practical telegraphing, when a relay-magnet is connected in what is usually designated the *main circuit* for the purpose of transmitting signals to a *second main circuit* by means of a smaller magnet, which is adjusted in a local or short circuit, the two magnets thus connected and *used together* are called a "*repeater*," from the fact that this particular arrangement of the magnets in the main and local circuits causes every signal to be promptly repeated or transmitted from one main circuit to another at those places where, in the earlier days of telegraphing, a person was required to perform this labor. In the sketch, M is the *main* relay-magnet, and L the *local* magnet.

With these two magnets signals can be transmitted only in *one* direction; hence, for the convenience of sending signals in either direction, a relay-magnet is required in *each* of the two main circuits, which in turn must be connected with its smaller magnet in a local circuit. The sketch represents repeaters arranged for transmitting signals in either direction.

The *eduction time* of a single relay-magnet was first determined, then a single repeater was connected in the clock circuit, B, B^1 , after which a second repeater was added, then a third, and finally a fourth. Thus we were enabled to determine the *total eduction time* of four repeaters and one relay-magnet, and at the same time to ascertain the *eduction time* of each particular repeater.

The recapitulation of the results thus obtained is presented in the accompanying table, No. 1; each result is the mean of ten comparisons as recorded upon the fillet paper.

From a casual inspection of these results it will be observed that the retardation or loss of time in the transmission of signals through a telegraph repeater will vary according to the construction and adjustment of each particular instrument. In the repeaters designated as No. 1 and No. 2 in Table No. 1, each main relay was three inches in length, and upon each spool (two of which form the main helix) were twenty-three coils of No. 30 silk insulated copper wire, the entire length of which was about 2,200 feet. The local helices were one and a half inch in length, and one and a fourth in diameter, and each spool contained sixteen coils of No. 22 silk insulated copper wire. The length of the wire upon each local helix was estimated to be between seven and eight hundred feet.

In the repeaters designated No. 3 and No. 4 in Table No. 1, the main relay was four and a half inches in length, and each spool of the main helix contained thirty coils of No. 35 silk insulated copper wire, the length of which was estimated to be 3,600 feet.

The local helices were one and a half inch in length and one inch in diameter. There were fourteen

layers of No. 24 silk insulated copper wire upon each spool, and the length of wire in each helix was estimated to be about eight hundred feet.

The diameters of the wires upon the several helices were carefully measured and found to be as follows:

Wire No. 22 was 0.031 of an inch in diameter.

Wire No. 24 was 0.026 of an inch in diameter.

Wire No. 30 was 0.017 of an inch in diameter.

Wire No. 35 was 0.015 of an inch in diameter.

On referring to Table No. 1 it will be noticed that the average *eduction time* of repeaters No. 1 and No. 2, with a maximum tension of the armature spring, was a little more than one-hundredth of a second of time, and with a minimum tension it was four-hundredths of a second; while repeaters No. 3 and No. 4, with a maximum tension, indicated an average *eduction time* of six-hundredths, and with a minimum tension of twelve-hundredths of a second.

The resistance in the helices of repeaters No. 3 and No. 4 was found to be considerably greater than in those of No. 1 and No. 2. This result was expected from the difference in the size and length of wire in the respective coils, though the large difference of the *eduction time* in the several instruments could only in part be attributed to that cause. The experiments which were made with a *maximum* tension of the armature spring clearly indicated that this difference of the *eduction time* was chiefly due to the difference in the construction of the helix cores or soft iron bars.

I think these experiments conclusively demonstrate the fact which Professor Henry many years ago discovered, viz: that the greater the length of the helix core the longer will be the *induction* or *eduction* time of the electro-magnet, other conditions being the same.

Of this discovery by Professor Henry I had no knowledge whatever until I had submitted the results of a series of experiments to him for the purpose of obtaining his views as to the best method for conducting further researches, and I would here express my sincere thanks to him for the very friendly interest which on all occasions he exhibited in these experiments, and for the many suggestions which I received from him.

Professor Henry proposed having the helix cores composed of small well-annealed insulated iron wire, by which the *induction* or *eduction* time would be diminished. The experiments which I had already completed showed that the cores should have a maximum length consistent with the magnetic power required from each relay coil. I accordingly prepared drawings for the construction of a helix which should be provided with several movable cores made of small iron wire insulated with silk. The instrument was manufactured with great care by Mr. E. M. Pierson, telegraph instrument maker, at Cleveland, Ohio, now of Newark, New Jersey.

To Mr. George B. Hicks, of Cleveland, inventor of the "*Hicks's telegraph repeater*," I was indebted for valuable aid in superintending the construction of this instrument.

For greater convenience in making these experiments the instrument was provided with two movable main helices, each two and three-fourths inches in length and one and a half inch in diameter. The helix, which I here designate as No. 1, consisted of forty coils of No. 30 silk insulated copper wire, divided into three series or sections. The first series was of twelve coils, around a thin paper tube, sufficiently large to admit the different iron cores without difficulty. Its length upon each spool was 300 feet. The second series was of twelve coils, immediately around the first, the length being 450 feet. The third was of sixteen coils, around the second, the length 675 feet, thus making the entire length of wire upon each spool 1,425 feet, or 2,850 feet on the two.

The object of dividing each coil into series was to determine the minimum length of wire required upon the helix to produce the necessary magnetic power in the electro-magnet. This was satisfactorily done by first using series No. 1, then series one and two, and finally the three series together.

The length and diameter of the spools of helix No. 2 were the same as those of No. 1.

The first series consisted of fourteen coils of No. 35 silk insulated copper wire around a thin paper tube similar to that used in helix No. 1. The length of wire, in this series, upon each spool was 450 feet. The second series was of fourteen coils, immediately upon the first, the length of which was 600 feet. The third series consisted of eighteen coils, around the second, the length being 1,110 feet, thus making the entire length of wire upon each spool 2,160 feet, or 4,320 feet on the two.

The experiments with this helix were in all respects similar to those made with helix No. 1, and from the results obtained (see Tables Nos. 2 and 3) it appeared that the magnetic power of the electro-magnet, having twenty-four coils of No. 30 copper wire upon its helix, was about the same as when forty coils were

used, thus showing that with the same battery force there was no advantage gained by increasing the number of coils from twenty-four to forty. And since these experiments were made under conditions similar to those which are frequently encountered in practical telegraphing through circuits of two or three hundred miles in length, (at least so far as the same resistance in the conducting wires could make the conditions similar,) I infer that no practical advantage can be obtained by increasing the number of coils upon the telegraph relay-magnet above twenty-five or thirty, unless we increase in a corresponding ratio the size of the iron wire now in general use upon most of the telegraph lines in the United States.

I shall again have occasion to refer more particularly to this subject before closing this report.

With helix No. 2 (see Table No. 3) the power of the electro-magnet was found to be *considerably less* when forty-six coils of No. 35 copper wire were upon the helix than when only twenty-eight were used, the battery being the same in both cases.

From a further comparison of the results in these tables it will be observed that the magnetic power of helix No. 1 was much greater than that of No. 2, while a much larger battery was required to overcome the resistance through the No. 35 copper wire with which the latter was constructed, thus confirming the opinion which I have already expressed in regard to the importance of increasing the size of the wire now in general use for telegraph purposes.

The iron cores were constructed in the following manner:

Core No. 1 consisted of two solid soft iron bars, each three inches in length and half an inch in diameter.

Core No. 2 was of the same length and diameter as No. 1, but constructed of well-annealed and insulated iron wire bars, each one-tenth of an inch in diameter.

Core No. 3, of similar dimensions as No. 1 and No. 2, was constructed of well-annealed iron wire six-hundredths of an inch in diameter, and insulated with silk.

Core No. 4 was in all respects similar to No. 3, with the single exception that the iron wire used was but three-hundredths of an inch in diameter.

My first object was to ascertain the relative magnetic power which could be obtained from each of these cores, which I accomplished in the following manner:

The helix constructed of the No. 30 wire was adjusted in a vertical position, so as to allow the several iron cores to be placed consecutively within it while connected in the galvanic circuit. Immediately in contact with the lower surface of the core was placed a soft iron plate similar to that generally used upon the armature of a relay-magnet; this plate was well insulated with silk, and from its centre was suspended a small cup into which mustard-seed shot were slowly dropped until the weight became just sufficient to overcome the attractive force of the magnet, and thus allow the plate to fall from the surface of the core. The exact weight sustained by each core at each consecutive trial was ascertained with a delicate balance which was obtained at the Coast Survey office for this purpose.

Table No. 2 contains a recapitulation of the weights sustained by each core when used in helix No. 1, and Table No. 3 those sustained by the same cores when used in helix No. 2.

From a comparison of these results it will be noticed that the magnetic power of the electro-magnet rapidly diminishes as we diminish the *diameter* of the wire with which the magnet cores may be constructed. In practical telegraph operations we should expect to encounter many difficulties in attempting to exchange signals upon lines from 200 to 500 miles in length with electro-magnets having so little magnetic power as that which was obtained from cores No. 3 and No. 4 under the most favorable conditions. I have no reason to doubt, however, that core No. 2, adjusted in helix No. 1, would perform very satisfactorily in a well-insulated circuit of 200 or 300 miles under favorable conditions of the atmosphere, but during sultry, foggy, or rainy weather, core No. 1 would undoubtedly be found much superior to No. 2.

Tables No. 4, No. 5, and No. 6, contain a recapitulation of the results of the relative *eduction time* of the several cores under similar conditions.

It will be noticed that the *eduction time* of cores No. 2, No. 3, and No. 4, was, upon the average, *less than one-hundredth of a second of time*, while in core No. 1 it varied from one to four hundredths of a second, depending upon the adjustment of the armature spring. The reason for this large difference between core No. 1 and the others was chiefly due to the difference of the magnetic power of the several cores as exhibited in Tables No. 2 and No. 3. The comparatively small variation of the *eduction time* in cores No. 2, No. 3, and No. 4, when the armature spring was adjusted first at a maximum and then at a minimum tension, must, I think, be attributed to the same cause, thereby permitting but very slight change in this adjustment of the instrument.

After the foregoing experiments had been completed, and the results submitted to Professor Henry for his inspection, he suggested that if a narrow groove were cut lengthwise and to the centre of each bar of core No. 1 perhaps the *eduction time* would thereby be somewhat diminished. I accordingly carried the suggestion into execution, and the results herewith presented in table No. 7 prove his theoretical deductions to have been well founded.

So far as I am informed on this subject, the first experiments undertaken for the purpose of measuring the absolute *induction* or *eduction time* of an electro-magnet by means of a well-regulated clock were made during the winter of 1858 by Assistant J. E. Hilgard, aided by Assistant Edward Goodfellow.

Some two years ago Mr. Hilgard very kindly permitted me to look over his results, and I have no doubt that a comparison between them and those of a similar class herewith presented would show a very close agreement, although the method adopted by Mr. Hilgard was somewhat different from that pursued by myself.

Since these experiments were undertaken for the specific purpose of determining, so far as practicable, the best mode of constructing electro-magnets intended to be used as relays for transmitting with the least loss of time signals through long telegraph circuits, I respectfully beg leave to offer a few suggestions in regard to the construction of telegraph instruments, and the size and quality of iron wire which, in my judgment, is most suitable for telegraph purposes; a subject which has at different times engaged my attention while conducting for several years past the telegraph longitude operations of the Coast Survey under your directions.

In the construction of telegraph instruments generally, and more particularly of electro-magnets, no definite system based upon accurate experiments appears to have been adopted in the United States having in view the length, size, and quality of the wire circuits in which such instruments were designed to be used; consequently we find as many electro-magnets of different forms of construction (of both good and bad quality) as there are persons engaged in manufacturing them. So far as I have been able to learn, each instrument-maker has established certain rules of his own for determining the dimensions and form of each particular piece of his instrument; hence, one will construct his relay-magnets with cores *three* inches in length and *half* an inch in diameter, with twenty-five or thirty coils of No. 35 copper wire upon the helix. A second makes his cores *four* inches long, only *three-eighths* of an inch in diameter, and with twenty-five coils of No. 30 copper wire upon the helix, while a third constructs them *four and a half* inches in length and *half* an inch in diameter, with thirty coils of No. 35 copper wire.

These relay-magnets, so entirely different in their construction, are frequently used indiscriminately in circuits varying from one hundred to five hundred miles, the result of which is that great difficulty is often experienced in exchanging signals between distant stations.

It seems to me plain that an electro-magnet having its cores *three and a half* inches in length and *five-eighths* of an inch in diameter, with *thirty* coils of No. 30 copper wire upon the helix, will perform more satisfactorily in a circuit four or five hundred miles in length than one with cores *three* inches in length and but *three-eighths* of an inch in diameter, and with only *twenty* coils of No. 30, or perhaps No. 35, copper wire upon the helix.

It is well known that as the length of the circuit is increased the resistance against the battery current is also greatly increased; hence, to obtain the requisite magnetic power in an electro-magnet which is to be used in a circuit of five hundred miles, we should determine by a complete series of experiments what dimensions should be given to the iron cores, and what number of coils and what size of copper wire ought to be used upon the helix, to produce a maximum power with a minimum current, in connexion with the least *induction* and *eduction time* in the electro-magnets.

The results of the recent experiments have led me to the conclusion that a relay instrument having its iron cores three inches in length and five-eighths of an inch in diameter, with thirty coils of No. 30 copper wire upon its helix, will approximately fulfil these conditions, and with your permission I am now having constructed for the Coast Survey four such instruments, which are to be used in making future determinations of differences of longitude with the electro-magnetic telegraph. It would be expecting too much to suppose that these instruments will at once fully meet all the requirements demanded for the successful execution of the proposed important but difficult longitude operations, and I have no doubt that further experiments will lead to additional modifications and improvements in electro-magnets.

In the United States much study has already been given to the subject of insulation of telegraph lines, while the equally important matter of improving the quality and increasing the size of the iron wire in general use for telegraph purposes has, with a few exceptions, been almost entirely overlooked.

Most of our telegraph lines were originally constructed with wire known commercially as No. 10, which is 0.14 of an inch in diameter, and in some instances No. 11 and No. 12 were used, which are respectively 0.13 and 0.12 of an inch in diameter.

It did not, however, require many years' experience to show that those lines which were constructed of the largest wire possessed several advantages over those in which No. 11 and No. 12 wire were used, and the result has been that upon the principal lines No. 8 and No. 9, each respectively 0.16 and 0.15 of an inch in diameter, have been substituted for No. 10 and No. 11.

Further than this the improvement of the telegraph lines appears to have made but little progress, and I think that I am safe in estimating that at least seven-eighths of our telegraph lines are constructed with No. 8 and No. 9 wire. The exceptional cases are those where a few lines have been constructed with No. 6 iron wire, which is 0.22 of an inch in diameter, through which signals may be exchanged with greater facility than could possibly be done over lines located upon the same routes but constructed of smaller wire.

It is quite evident that this should be the case, because the resistance in the larger wire is much less than in the smaller, and where it has been found otherwise in practice it must have resulted from a less perfect insulation, or, what is still more probable, from the use of an *inferior quality of wire*. Of course the quality of the iron used in manufacturing the larger wire should be equally good with that used for the smaller, and certainly not less attention should be given to the annealing process, for unless we attend to both these points we shall make very little improvement by increasing the size of the wire.

After much careful reflection on the subject I have been led to the conclusion that if all the principal telegraph lines in the United States could be partially reconstructed by substituting No. 6, or, better still, No. 5 iron wire of the best quality, it would, in the end, prove highly advantageous to the several companies. This opinion is based upon the following reasons:

In those sections where dense fogs prevail for weeks in succession, as near the sea-coast of Maine and the British provinces, California and Oregon upon the Pacific coast, and also where it becomes necessary to construct lines through swamps or over low, wet prairies, which are frequently encountered in the southern and western States, the lines will, during such times, be enveloped with moisture, thereby greatly impairing the insulation, and thus reducing the working condition to a minimum standard. The usual remedy under such circumstances is an increase of battery power; but when wire no larger than No. 8 or No. 9 is used this is not always successful, from the want of capacity of the wire. On the other hand, if No. 5 or No. 6 iron wire of the best quality were used, instead of No. 8 or No. 9, the difficulties to which I have alluded could be successfully overcome in foggy or stormy weather by increasing the batteries, and, under the more favorable conditions, *less* battery would be required for operating the line.

Upon an average the battery power used in operating the various telegraph lines in the United States is equivalent to one Grove cell for every five miles of wire in the circuit, whereas by increasing the size of the wire from No. 8 to No. 5 or No. 6 I am quite confident that the amount of battery absolutely required for all practical purposes could be reduced twenty per cent., perhaps more, an item of economy in the operating expenses which would very soon cancel the additional expenditure required for the improved construction.

In regard to the advantages or disadvantages of using galvanized iron wire, my opinion is that when annealed iron wire of good quality is properly galvanized it will be both better and more economical for telegraph purposes. In exceptional cases, where it may be found otherwise, an examination will undoubtedly prove that the wire had been manufactured from an inferior quality of iron, or, perhaps, damaged by fire or water to such a degree as to have rendered it unsalable until its imperfections were covered by being galvanized.

Very respectfully submitted by

GEORGE W. DEAN,
Assistant U. S. Coast Survey.

Prof. A. D. BACHE,
Supt. U. S. Coast Survey.

TABLE No. 1.—*Eduction time in transmitting signals through telegraph "repeaters."*

Date.	Series.	No. of cells in battery.	The tension on the armature spring at a maximum and minimum.									
			Relay-magnet.		Repeater No. 1.		Repeater No. 2.		Repeater No. 3.		Repeater No. 4.	
			Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.
March 14, 1863.....	1	3	.000	.....	.020	.....	.010	.....	.050	.....	.060	.....
	2	3	.010	.....	.020	.....	.020	.....	.040	.....	.100	.....
	3	1	.....	.010	.....	.020	.....	.020	.....	.140	.....	.180
	4	1	.....	.026	.....	.023	.....	.028	.....	.160	.....	.113
March 23, 1863.....	5	1	.....	.008	.....	.020	.....	.029	.....	.100	.....	.187
	6	1	.....	.012	.....	.020	.....	.029	.....	.155	.....	.125
	7	1	.....	.010	.....	.033	.....	.025	.....	.073	.....	.208
	8	1	.....	.011	.....	.028	.....	.040	.....	.114	.....	.166
	9	1	.....	.016	.....	.031	.....	.031	.....	.096	.....	.181
	10	1	.....	.020	.....	.023	.....	.036	.....	.167	.....	.113
	11	1	.....	.014	.....	.027	.....	.029	.....	.091	.....	.196
			.....	.014	.....	.025	.....	.030	.....	.122	.....	.163
March 24, 1863.....	12	3	.....	.024	.....	.074	.....	.089	.....	.102	.....	.080
	13	3	.....	.015	.....	.049	.....	.050	.....	.054	.....	.117
	14	3	.....	.013	.....	.075	.....	.047	.....	.070	.....	.047
	15	3	.....	.011	.....	.067	.....	.022	.....	.072	.....	.042
	16	3	.....	.014	.....	.052	.....	.025	.....	.082	.....	.152
	17	3	.....	.020	.....	.044	.....	.032	.....	.089	.....	.153
	18		.....	.015	.....	.010	.....	.024	.....	.034	.....	.095
	19		.....	.024	.....	.017	.....	.015	.....	.045	.....	.086
			.....	.013	.....	.013	.....	.016	.....	.044	.....	.100

NOTE.—When the tension of the armature spring was at a minimum, the circuit remained open about one-tenth of a second when each signal was made; and with a maximum tension of the spring, it continued open between three and four-tenths of a second.

TABLE No. 2.—*Experiments for testing electro-magnets of different constructions.*

Date.	Coils of wire on helix.	Length of No. 30 wire on helix.	No. of cells in battery.	Galvanometer reads—		Weight in grains sustained by each core.			
				Without helix in circuit.	With helix in circuit.	No. 1.	No. 2.	No. 3.	No. 4.
1864.		<i>Fet.</i>		<i>c</i>	<i>c</i>	<i>Gr.</i>	<i>Gr.</i>	<i>Gr.</i>	<i>Gr.</i>
January 25.....	24	1500	1	18	3.5	632	.....	.....	.....
	24	1500	1	18	3.5	6131	2872	1891	793
	24	1500	1	18	3.5	6215	2739	1876	819
						6126	2815	1853	806
January 25.....	40	2850	1	.....	2.0	5626	.....	1309	486
	40	2850	1	.....	2.0	5700	.....	1326	516
						5663	.....	1323	501
January 29.....	40	2850	2	23	2.5	7627	2100	2021	991
		2850	2	23	2.5	7485	2006	1980	970
						7556	2053	2000	980
					
January 29.....	24	1500	2	.....	4.5	7626	2983	3198	1600
		1500	2	.....	4.5	7500	2950	3110	1646
						7563	2976	3154	1625
January 29.....	40	2850	2	.....	2.5	7500	.....	.....	.....
		2850	2	.....	2.5	7625	.....	.....	.....
						7562	.....	.....	.....

NOTE.—The copper wire on the helix was No. 30, or 0.017 of an inch in diameter.

TABLE No. 3.—*Experiments for testing electro-magnets of different construction—Continued.*

Date.	Coils of wire on helix.	Length of No. 35 wire on helix.	No. of cells in battery.	Galvanometer reads—		Weight in grains sustained by each core.			
				Without helix in circuit.	With helix in circuit.	No. 1.	No. 2.	No. 3.	No. 4.
1864. January 30.....	28	<i>Fect.</i> 2100	5	o 32	o 1.5	<i>Grs.</i> 1716	<i>Grs.</i> 550	<i>Grs.</i>	<i>Grs.</i> 360
	28	2100	5	32	1.5	1829	490	.....	356
						1773	520	.....	358
January 30.....	46	4320	5	.....	1.0	1565	Less than 300 grs.	Less than 300 grs.	Less than 300 grs.
	46	4320	5	.....	1.0	1700	.....	.....	303
						1632	.....	.....	.....
January 30.....	28	2100	5	.....	2.0	2209	621	355	503
	28	2100	5	.....	2.0	2215	610	310	486
						2227	645	318	494

NOTE.—The copper wire on the helix was No. 35, or 0.013 of an inch in diameter.

TABLE No. 4.—*Experiments for determining the eduction time of electro-magnets of different construction.*

Date.	Coils of wire on helix.	Length of wire on helix.	No. of cells in battery.	The tension on the armature spring at a maximum and minimum.							
				No. 1.		No. 2.		No. 3.		No. 4.	
				Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.
1864. February 5	24	1500	2	<i>Sec.</i> .011	<i>Sec.</i> .008	<i>Sec.</i> .010	<i>Sec.</i> .021	<i>Sec.</i> .011	<i>Sec.</i> .013	<i>Sec.</i> .009	<i>Sec.</i> .013
		(No. 30.)									
February 6	24	1500	2	.005	.037	.004	.010	.006	.013	.004	.012
	24	1500	2	.007	.010	.008	.017	.009	.021	.009	.012
	24	1500	2	.009	.044	.009	.013	.007	.011	.008	.010
				.008	.037	.008	.015	.008	.014	.007	.012
February 8	46	4320	3	.003	.031	.001	.012	.002	.005	.005	.002
		(No. 35.)									
	46	4320	3	.006	.038	.002	.005	.000	.010	.008	.002
	46	4320	3	.003	.040	.002	.005	.000	.010	.002	.006
	46	4320	3	.003	.043	.002	.008	.004	.006	.003	.007
				.004	.039	.001	.007	.002	.008	.004	.005

TABLE No. 5.

NOTE.—The following experiments were made with a battery of twenty cells, in a circuit of about two miles in length, composed of No. 30 and No. 35 copper wire. The resistance was made equal to that usually found upon telegraph lines 200 or 300 miles in length by interposing water in the circuit.

Date.	Coils of wire on helix.	Length of No. 30 wire on helix. <i>Feet.</i>	Number of cells in battery.	Galvanometer reads—		The tension of the armature spring at a maximum and minimum.							
				With 150 feet wire in circuit.	With helix and water interposed in circuit.	No. 1.		No. 2.		No. 3.		No. 4.	
						Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.
1861. February 26.....	24	1,500	20	0 71	0 2.0	<i>Sec.</i> .003 .002	<i>Sec.</i> .032 .017	<i>Sec.</i> .003 .002	<i>Sec.</i> .003 .019	<i>Sec.</i> .010 .007	<i>Sec.</i> .011 .012	<i>Sec.</i> .003 .002	<i>Sec.</i> .009 .007
						.003	.025	.003	.010	.002	.012	.003	.008
March 5.....	24	1,500	20	31	1.5	.006 .003	.020 .021	.004 .004	.013 .015	.002 .003	.015 .008	.001 .001	.004 .009
						.004	.020	.004	.014	.003	.007	.001	.006

TABLE No. 6.

NOTE.—The following experiments were made with the same battery (20 cells) and under similar conditions as those given in the preceding table with the single exception that a different helix was used.

Date.	Coils of wire on helix.	Length of No. 35 wire on helix. <i>Feet.</i>	Number of cells in battery.	Galvanometer reads—		The tension of the armature spring at a maximum and minimum.							
				With 150 feet of wire in circuit.	With helix and water interposed in circuit.	No. 1.		No. 2.		No. 3.		No. 4.	
						Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.
1861. February 27.....	46	4,320	20	0 75	0 1.5	<i>Sec.</i> .003	<i>Sec.</i> .036	<i>Sec.</i> .000	<i>Sec.</i> .004	<i>Sec.</i> .004	<i>Sec.</i> .014	<i>Sec.</i> .000	<i>Sec.</i> .003
	46	4,320	20	75	1.5	.001	.037	.003	.009	.005	.014	.002	.009
						.002	.036	.002	.007	.004	.014	.001	.006
March 5.....	46	4,320	20	31	1.5	.005	.033	.004	.010	.003	.009	.003	.007
	46	4,320	20	31	1.5	.006	.034	.008	.011	.005	.010	.001	.008
						.005	.033	.006	.010	.004	.009	.004	.008

TABLE No. 7.

NOTE.—The following experiments were made with core No. 1 after a narrow groove had been cut lengthwise and to the centre of each bar.

Date.	Coils of wire in helix.	Length of No. 35 wire in helix.	Number of cells in battery.	Galvanometer reads—		The tension on the armature spring at a maximum and minimum.	
				With 150 feet of wire in circuit.	With helix and water interposed in circuit.	No. 1.	
						Maximum.	Minimum.
1864.		<i>Feet.</i>				<i>Sec.</i>	<i>Sec.</i>
March 1	46	4,320	20	46	1.5	.003	.030
	46	4,320	20	46	1.5	.002	.038
						.003	.024
March 1	28	2,100	20	46	1.5	.004	.027
	28	2,100	20	46	1.5	.004	.033
						.004	.030
March 1	40	2,850	20	46	1.5	.003	.027
	40	2,850	20	46	1.5	.004	.038
						.004	.032
March 1	24	1,500	20	46	1.5	.002	.040
	24	1,500	20	46	1.5	.002	.035
						.002	.037

APPENDIX No. 21.

COMMUNICATION ON THE TRAJECTORY OF RICOCHET SHOT FROM A 15-INCH RODMAN GUN. BY CHARLES A. SCHOTT, ASSISTANT U. S. COAST SURVEY.

COAST SURVEY OFFICE, July 19, 1864.

On the 1st and 2d of July, 1864, some shells were thrown experimentally along the channel of the Potomac from two 15-inch guns, mounted at Battery Rodgers and Fort Foote, in order to ascertain their ranges and other circumstances at various elevations. These experiments were made under the immediate direction of General Howe, assisted by Major Hamlin. The operations for the determination of the distances were attended to by myself.

At each place a base line was measured with a steel band, (corrected for temperature,) one end of which was the point of observation for the flight of the shell; the distance of this point from the gun became known by the measure of the angles of the triangle. The distances to some other range objects from the gun were also determined. The angle at the gun between the line of fire (a fixed direction) and the point of observation was measured, as well as the various angles at the latter point, between the gun and the successive impacts of the shot. The ranges, in which these impacts were seen by the observers, clustered for this purpose closely around the central stake, were marked out by stakes in the order in which they occurred, the observers having previously been numbered for this purpose. The angles were measured afterwards with a theodolite. The ranges of the first impact, and of several following ones, as well as the total range, were then computed. Tables were also computed for directions, to be marked by stakes intersecting given constant distances on the line of fire, for the use of future experiments. The results were also graphically laid down.

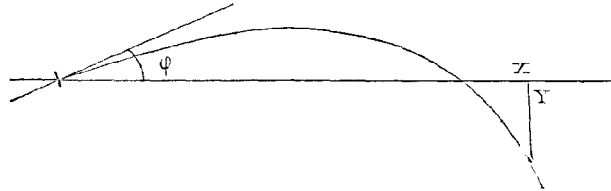
Thinking that a further development of Poisson's formula to meet the case of a ricochet shot might be

of interest and use for the construction of practical tables of ranges, the same is herewith appended, together with an illustration.

For elevations less than 10° , which includes the above experiments, as the ball will not ricochet even with 5° elevation at certain heights above the tide-water, Poisson gives the expression:

$$y = xtg\varphi - \frac{gx^2}{2V^2 \cos^2 \varphi} \left(\frac{2}{3}kx + 1 \right),$$

where,



y = vertical ordinate of any point in the trajectory.

x = its horizontal ordinate, the origin being at the mouth of the gun.

φ = elevation of gun; for small angle $\cos^2 \varphi$ differs but little from 1.

g = force of gravity = 10.733 yards.

V = velocity of projectile when leaving the gun = $\sqrt{2gh}$.

q = experimental coefficient, generally assumed = 0.225.

δ = density of air.

δ' = density of projectile.

r = radius of projectile.

and $k = \frac{q\delta}{r\delta'}$.

The resistance of the air is assumed proportional to the square of the velocity. If either the initial velocity is determined directly and independently, or the time of flight is experimentally ascertained, the coefficient, k , becomes known. We have,

$$\frac{2}{3}k = \frac{2V^2(xtg\varphi - y)}{gx^3} - \frac{1}{x}.$$

$$V = \sqrt{\frac{gx^2(\frac{2}{3}kx + \frac{1}{2})}{xtg\varphi - y}}.$$

$$t = \frac{e^{kx} - 1}{k\sqrt{2gh} \cos \varphi}, \text{ or, near enough, } t = \frac{e^{kx} - 1}{kV}.$$

$v = Ve^{-kx}$ the velocity at any other point.

$e = 2.71828$, the base of Napierian log's.

The above-mentioned experiments were not made with a view of determining k ; we have, therefore, given, φ , x , y , or the height of the gun above the Potomac, viz: $y = -11.7$ yards for the battery, and $y = -30.0$ yards for the fort, and with $q = 0.225$, $r = 0.18$, (allowing for windage,) $\delta = \frac{1}{800}$, (allowing for temperature,) and $\delta' = 7$, k becomes 0.000225 very nearly; φ being also known, (it was varied from 0° to 3° .) the initial velocity, V , from four experiments at the battery, was found = 387 yards, and from three experiments at the fort = 393 yards; the average, or 390 yards, for a ball of about 300 pounds and a charge of 40 pounds of powder, is a tolerable approximation to the value found by Captain Rodman. The assumed value of k appears somewhat too great. We take, as a special case, the investigation of the trajectory of the second shot fired at Fort Foote, the elevation being 2° . The ranges were measured as follows:

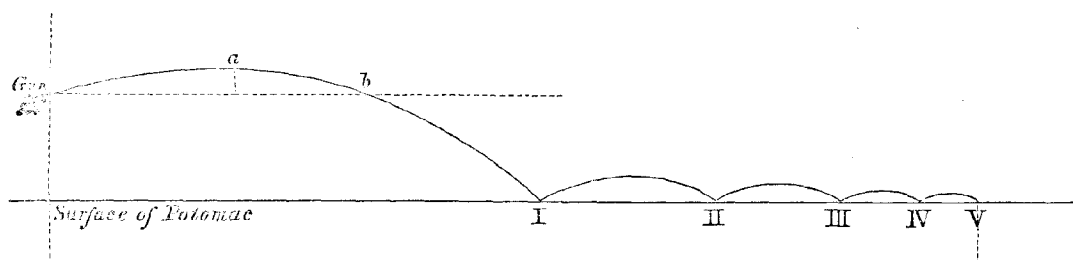
From gun to first impact, 1,334 yards; bound, 544 yards.

From gun to second impact, 1,878 yards; bound, 327 yards.

From gun to third impact, 2,205 yards; bound, 195 yards.

From gun to fourth impact, 2,400 yards; bound, 149 yards.

From gun to last impact, 2,549 yards.



Substituting $y = -30.0$, $x = 1334$, $\varphi = 2^\circ$, and $k = 0.000225$, in the expression for V, we find the initial velocity $= 387$ yards; and from the expression for t , the time of flight $= 4.302$, also the velocity just before the first impact, $v = 286$ yards. To find the horizontal range, put $y = 0$, hence $tg\varphi = \frac{gx}{2V^2} + \frac{kgx^2}{3V^2}$; or,

$$x = \frac{-\frac{1}{2} + \sqrt{\frac{1}{4} + \frac{4tg\varphi kV^2}{3g}}}{\frac{2}{3}k} = 862 \text{ yards} = \text{distance gun to } b. \text{ For the highest point, } a, \text{ of the trajectory we}$$

have, from the condition of the maximum, $0 = tg\varphi - \frac{x^2kg}{V^2} - \frac{xg}{V^2}$, or $x = \frac{-1 + \sqrt{1 + 4tg\varphi kV^2}}{2k} = 443 \text{ yards,}$

the corresponding y becomes 8.0 yards, which is the greatest elevation of the shell above the level of the gun; it takes place 12 yards beyond the middle distance from the gun to the point b . To find the angle of impact we differentiate the equation, and obtain

$$\frac{dy}{dx} = tga = tg\varphi - \frac{xg}{V^2}(1 + xk) = -5^\circ 07'.$$

In the absence of any other information, we can assume, without much liability to error, that notwithstanding the loss of velocity arising from the impact, the angle of rebound equals $5^\circ 07'$; and taking this value for φ , 544 for x , $0 = y$, we find the corresponding velocity after the first impact,

$$V_1 = \sqrt{\frac{gx(\frac{2}{3}kx + 1)}{2tg\varphi}} = 188,$$

hence, the loss of velocity by the impact,

$$\frac{286 - 188}{286} = 0.34 \text{ parts.}$$

Thus taking a new departure from the point of first impact, the preceding formula apply again to trace out the trajectory to the second impact, and similarly for the next and all following bounds, treated as so many independent level ranges. We have, accordingly, terminal velocity of first bound, 166 yards; initial of the second, 138; hence loss at second impact, 0.17 parts; terminal velocity of second bound, 128 yards; initial of the third, 103; loss by third impact, 0.20 parts; terminal velocity of third bound, 99 yards; initial of fourth, 88; loss by fourth impact, 0.11 parts; and the final velocity with which the projectile plunges into the water, 85 yards a second. The angle of impact and rebound at the second impact is $5^\circ 31'$, at the third $5^\circ 47'$, at the fourth $6^\circ 00'$, and at the last or final disappearance $6^\circ 10'$. Greatest elevation of projectile above surface of water in first bound, 12.6 yards, (which takes place 5 yards beyond the middle point of its length;) greatest elevation of second bound, 8.0 yards; of third, 5.0 yards; and of the last, 4 yards. A ball may, therefore, bound over a small vessel sitting low in the water, if midway between the first and second impact, or even between this and the third point of impact. The times of flight of the successive bounds are 3.08, 2.46, 1.93, and 1.72; total, including the first branch of the curve $= 13.21$. If the time of each bound was observed, or even that of the total flight, allowance could be made for any possible difference in the angle of impact and rebound; should the latter be found smaller, it would be indicated by a shorter flight than the computed one. The vertices of the successive ricochet bounds are nearly tangential to a straight line inclined about half a degree to the horizon.

APPENDIX No. 22.

REPORT ON THE DETERMINATION OF RANGES OF SHOT FROM 15 AND 20-INCH GUNS. BY CHARLES A. SCHOTT, ASSISTANT UNITED STATES COAST SURVEY.

COAST SURVEY OFFICE, *October 12, 1864.*

SIR: The following statement explains, in general terms, the nature of the inquiry and the operations performed while acting under your instructions, dated September 24, 1864, detailing me for special duty in New York and Boston harbors, to assist General A. P. Howe, inspector of artillery, United States army, in experiments of firing with 15-inch guns. I left Washington September 25, and returned October 9. The instruments used were a small theodolite, with 5-inch horizontal and vertical circles, and a steel band 20 metres in length. The ranges of the ricochet shot were determined as described in my report of July 19. It was found that a plumb-line suspended over the point of observation greatly facilitated the ranging in of the several impacts by the observers. At Fort Richmond, at the Narrows of New York bay, a base line was measured and connected by triangulation with the signals at the gun and the observing station. At the latter point a frame-work was put up, upon which the computed ranges, between 500 and 6,000 yards, were laid off, the line of fire being directed towards the Romer stone beacon. At Governor's island, New York bay, similar measures were taken, with a line of fire directed towards a shot tower on Staten Island. The elevation of the guns above the half-tide level was also determined. In Boston harbor the position of two guns, on Governor's island, and of the observing station at the northeast salient angle of Fort Independence, Castle island, were determined by means of horizontal angles between known objects.

Nine shots were fired from two guns at Fort Richmond, and fifteen from two guns at Governor's island, Boston harbor. The range of the first bound, and the length of several succeeding bounds, as well as the extreme range, were determined. The charge of powder and projectile was varied; also the inclination of the axis of the gun. Results were obtained for the number of ricochets for a given inclination, and for that inclination which produces the maximum number of impacts. Experience was gained of the effect of the waves upon a ricochet shot. Two kinds of powder were tested, and the effect of greater charges of the ordinary (mammoth) powder measured. The recoil of the gun at each fire was noted. A detailed statement of the numerical results was submitted to General A. P. Howe.

On the 26th of October I assisted in determining the ranges of shot from the 20-inch gun mounted at Fort Hamilton, New York bay.

Yours, respectfully,

C. A. SCHOTT,
Assistant U. S. Coast Survey.

J. E. HILGARD, Esq.,
Assistant in charge U. S. Coast Survey Office.

APPENDIX No. 23.

AIDS TO NAVIGATION IN EASTPORT HARBOR AND PENOBSCOT BAY, RECOMMENDED BY ASSISTANT HENRY MITCHELL.

BROOKLINE, MASS., *September 5, 1864.*

DEAR SIR: Under the date of August 11 I had the honor to receive from you instructions to examine certain localities near Penobscot bay and Eastport, and to report upon the necessity of additional buoys or other aids to navigation. Your instructions were accompanied by copies of memorials from the citizens of Rockland, addressed to gentlemen of the board of light-house inspection. These papers I return as requested.

I respectfully recommend that spar buoys be placed upon the following obstructions: Gunning Ledge, Keel Rock, Grindstone Ledge, and Billing's Ledge.

I shall proceed to describe, in detail, the location and character of these dangers, and shall notice other obstructions, which I have examined, and which may hereafter be the subjects of further memorials. As there seems to be no limit to the wants of coasters in the way of buoys, &c., I have endeavored, in the above list, to distinguish the most serious objects of danger from among the great number pressed upon my knowledge.

Herring Gut.—The excellent little harbor of Herring Gut is approached from the sea by three ship channels, the most eastern and least direct of which lies between the Brothers and Mosquito island. The obstacles in this approach are all well marked, with the exception of "Gunning Ledge"—a sunken reef of a very dangerous character. The shallowest and most seaward portion of this reef lies two hundred and thirty metres N. by E. from the northern point of Gunning Rocks, and five hundred and forty metres N.W. by W. $\frac{1}{2}$ W. from the north point of the West Brother island. Five feet, at ordinary low water, covers the portion of this ledge to which I have referred, and its sheltered position usually protects it from breakers; the kelps, however, betray its whereabouts at low tidal stages. The sunken hulls of two vessels are said to be still occasionally seen near this reef when the water is low and clear.

As ships of the largest class seek a harbor in Herring Gut, I recommend that a buoy be placed, not upon the reef itself, but at a distance of one hundred and twenty metres N. by E., where a depth of three fathoms is reached at mean low water. This point lies upon the line between the north point of the West Brother and the light-house of Herring Gut, and is nearly on the sailing course. From this proposed site for the buoy the light-house will bear N.W. $\frac{3}{4}$ W. three-fifths of a mile distant, and the black buoy, which now marks a rock on the opposite side of this channel, N.E. $\frac{1}{2}$ E., one-third of a mile distant.

In the position I have described, I think a buoy will be an aid as well as a protection to navigation.

Within the harbor of Herring Gut there exists a small rock which ought to be marked. It lies on the west side of the anchorage, with the light-house bearing S. $\frac{1}{2}$ E., (about one-third of a mile distant,) and the wind-mill of South St. George bearing N.E. It is covered by two feet of water at ordinary low tides, and has about eight feet on either side of it. The three-fathom line of the basin lies within one hundred yards of this object when the tide is out. In foggy weather the harbor of Herring Gut is crowded with vessels of all sizes, and in the effort to secure berths in the basin they frequently strike this rock and lose portions of their keels or shoeing. Four *fore feet* of vessels, it is said, now lie on bottom near this rock; I did not see them. This object bears no name that I could learn; but I have referred to it in the preamble of this report as Keel Rock. Its proper marking is much desired by the citizens of South St. George.

My attention was called to the reefs extending into the harbor mouth from the rocky point on which the light-house stands. These reefs form a gradually inclined apron with two extending spurs. As the three-fathom line approaches everywhere within at least a thousand feet of the shore, and as the general aspect of the low rocky point indicates a dangerous approach, I failed to see the importance of further marks.

Comparatively few vessels pass *through* Herring Gut, the exit to the westward being obstructed by bars or shallow spits at the narrows off Alexander island, and by a flat sunken rock lying in the channel-way.

Muscle Ridge Channel.—This channel is one of the most frequented of the so-called *inland communications* along the coast of Maine. It lies within an irregular chain of islands, and extends from White-Head light to Fisherman's island, where it opens upon Penobscot bay. Its most direct approach for vessels from ports to the eastward of the bay is by way of the pass between Fisherman's and Sheep islands; but exaggerated reports of the dangers of this entrance induce many vessels to pursue the more tortuous but more distinctly marked channel under Owl's Head. These dangers consist of the Grindstone Ledge on the south and Sheep Island ledges on the north side of the ample channel-way.

Grindstone Ledge is an isolated rock, awash at low water of spring tides. In quiet weather the sea does not break upon it even at mean low water, but the kelps which grow upon it reveal its position to the observer. Four fathoms of water may be found in all directions within one hundred yards of this object, and upon the north side the same depth may be carried within thirty yards.

This rock lies about four hundred metres from the north shore of Fisherman's island, and may be found at any stage of the tide by the following: *With the double tree on the east end of Fisherman's island bearing S.E. $\frac{1}{4}$ E., run off till the "Yellow Ledge" is open half way between the aforesaid island and "Marble-Head Rock."* As the rock has a surface of some three hundred square feet, it can scarcely be missed in following these directions. Coasters have the following vague rule for clearing the Grindstone: Keep White-Head light open a hand-spike's length to westward of Otter island. Of course this rule is of no avail in thick weather.

I respectfully offer the opinion that a buoy near this rock would prove a protection to life and property, not only because it would warn vessels from the dangerous object itself, but also because it would reassure them in their apprehension of the Sheep Island ledges, the fear of which is augmented in foggy weather by the roar of their almost incessant breakers. It is not improbable that the rote of these ledges has often driven vessels too far over to the southward, and stranded them upon the Grindstone. With a buoy upon

the Grindstone, vessels may boldly run down in foggy weather till they make either this object or the bold shore of Fisherman's island, and thus this direct and ample entrance will lose its present bad name.

Sheep Is and Ledges.—By this name are distinguished three rocky spurs which extend from the north side of the entrance. Of these, the middle one terminates in a ragged pile of rocks, some six feet of which are exposed above the plane of low water, and this is the opposing danger to the Grindstone already described. This rocky pile is about three hundred metres from the shore of Sheep island, and very near the three-fathom line of the ship channel.

It appears to me that a buoy upon the Grindstone will obviate the necessity of the several buoys which the adequate marking of the Sheep Island Ledges would require. The channel is so ample that, with security upon the south, no vessels will be likely to venture over to these ledges, and, as far as I can learn, they have rarely been the *immediate* cause of disaster.

Complaint was made to me by the excellent Captain Sleeper, one of the petitioners whose name appears upon the documents enclosed with my instructions, that there is a rock beyond the "Breakwater Ledge," near Owl's Head cove, which frequently brings up coasting vessels. I examined the spot carefully, though not at low water. The ledge is now marked by a spindle, which is intended to indicate the position of this dangerous obstruction at high water. About one hundred feet beyond this spindle the ledge crops out again with but six feet upon its summit at very low tides. Captain Sleeper strongly urges the necessity of a buoy upon this outer rock. With plenty of sea room beyond it, and a very bold shore upon the opposite side of the channel, it would seem but a simple act of carelessness for a vessel to run one hundred feet from a spindle. At high water the outer rock has too much water upon it to fetch up the ordinary class of vessels seeking an anchorage in the cove; and at lower stages of the tide the exposed and ragged form of the ledge warns the stranger to keep his distance and to suspect hidden dangers. Upon this outer rock vessels have frequently lost shoeing and keels.

Billings's Ledge.—This obstacle would scarcely be classed as a danger to navigation, except from its proximity to the landings of the town of Eastport.

Billings's Ledge is a large flat-topped rock, nearly one hundred feet in diameter, which crowns a sandy shoal spot within two hundred yards of Bucknam's Head, (a rocky bluff at the SE. point of the island, upon which Eastport is built.) The shallowest portions of this rock are scarcely covered at the low water of spring, and its red color, as well as its eddies, make it conspicuous until the tide is pretty well up. With the rudest estimate of the distance I have given, it may be found at any stage of the tide by a single range. Bring the lone tree, on the western portion of Bucknam's Head in contact with the corner of Billings's house, (NW.)

This rock, situated almost under the shadow of Bucknam's Head, and approachable by the lead, must be regarded as an insignificant object of apprehension to the careful helmsman. I, however, recommend that a buoy be placed upon it. The great rise of the tides upon the bold shores in the neighborhood makes a very close approach to many of the rocky headlands a matter of safety and perhaps of convenience.

The range of spring tides at Eastport is 21 feet.

The time consumed in my examinations was lengthened by the heavy fogs which prevailed.

Very respectfully yours,

HENRY MITCHELL,
Assistant United States Coast Survey.

Professor A. D. BACHE,
Superintendent United States Coast Survey.

APPENDIX No. 24.

Aids to navigation placed or recommended by Coast Survey assistants, and referred for the information of the Light-house Board.

Section.	Object.	Assistants.	Date of report, &c.
I.	Spar buoy on Billings's Ledge, Eastport harbor, Maine.	Assistant H. Mitchell	Recommended to the Light-house Board.
I.	Spar buoy in 3 fathoms N. by E. of Gunning Ledge, Herring Gut harbor, Penobscot bay.	.....do.....	Do.
I.	Buoy to mark a rock on the west side of the anchorage in Herring Gut harbor.	.....do.....	Do.
I.	Spar buoy near Grindstone Ledge, Muscle Ridge channel, Penobscot bay.	.....do.....	Do.
I.	Two buoys in St. George's river, Me.; one to mark the ledge between the western mouth of Herring Gut and Caldwell's island; the other on the ledge making off from Stone Point.	Sub-assistant F. P. Webber	Recommended in report dated December 3, 1864.
II.	Two buoys set to mark the trial course for vessels of the U. S. navy in Raritan bay between Sandy Hook East Beacon, and Prince's Bay light.	Alex. Strausz, acting assistant. ...	For Navy Department, June, 1864.
IV.	The channel in Croatan sound, N. C., buoyed from Pork Point to Croatan light-house.	Sub-assistant J. S. Bradford	For North Atlantic Blockading Squadron, May, 1864.
IV.	Four buoys placed to mark the swash channel and course through Hatteras inlet into Pamlico sound, N. C.	Alex. Strausz and Edward Cordell, acting assistants.	For North Atlantic Blockading Squadron, March, 1864; October, 1864.
IV.	Three buoys set to mark the channel of Neuse river, N. C.	Alex. Strausz, acting assistant. ...	For North Atlantic Blockading Squadron, February, 1864.
IV.	Black buoy No. 3, red buoy No. 4, and black buoy No. 5, at Beaufort entrance, N. C., shifted in position to mark the line of best water found by resurvey.	Edward Cordell and Alexander Strausz, acting assistants.	For North Atlantic Blockading Squadron, April, 1864.
IV.	Three can buoys and numerous stakes set to mark the channel through Core sound and the straits, N. C.	.....do.....	For North Atlantic Blockading Squadron, September, 1864.

CONSOLIDATED ALPHABETICAL INDEX

OF THE

TEN ANNUAL COAST SURVEY REPORTS,

FROM 1854 TO 1863, INCLUSIVE.

PREPARED BY SUB-ASSISTANT F. F. NES.

[This Index, with that for this volume, and the Sketch Index, will supply references for all the matter in the Annual Coast Survey Reports published since 1853.]

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1854 :	33d	Congress,	2d	session,	Ex. Doc.	Senate No. —,	House of Representatives No. 20.
1855 :	34th	“	1st	“	“	“ 22,	“ “ 6.
1856 :	34th	“	3d	“	“	“ 12,	“ “ 18.
1857 :	35th	“	1st	“	“	“ 33,	“ “ —.
1858 :	35th	“	2d	“	“	“ 14,	“ “ 33.
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* Withdrawn : to appear in next annual report.

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